SOCIODEMOGRAPHIC, COGNITIVE, AND AFFECTIVE ANTECEDENTS TO PREGNANCY PLANNING AMONG WOMEN WITH DIABETES

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ABSTRACT

Laura Elizabeth Britton: Sociodemographic, cognitive, and affective antecedents to pregnancy planning among women with diabetes
(Under the direction of Diane Berry)

The prevalence of diabetes mellitus is increasing among women of reproductive age and can elevate risk during pregnancy of fetal malformation, perinatal loss, preeclampsia, preterm birth, and macrosomia. Those risks can be reduced by use of contraception until blood glucose is lowered, but current data suggests that women with diabetes are not consistently engaging in family planning practices. To facilitate the improvement of family planning services for women with diabetes, the goal of this three-paper dissertation was to describe the prevalence, racial and ethnic health disparities, contraceptive behaviors, and contraceptive attitudes of women with diabetes.

Aim 1 was to estimate the prevalence of diagnosed diabetes, undiagnosed diabetes, suboptimal preconception glycemic control, and prediabetes among women of reproductive age by race and ethnicity. Aim 2 was to distinguish the effectiveness of contraception used by women with diabetes and evaluate the hypothesis that women with diabetes used less effective contraception than women without diabetes. Aim 1 and Aim 2 were conducted using data from the National Longitudinal Study of Adolescent to Adult Health (Add Health), which contained biological and survey data from women aged 24−32 in 2007−2008. Aim 3 was to describe the attitudes of women with diabetes towards using contraception (including attitudes about the benefits, barriers, and self-efficacy related to contraception

use), for which primary data collection was conducted at a high-risk obstetrics clinic with postpartum women.

In Aim 1, our data supported the hypothesis that diabetes prevalence varied by race and ethnicity. The highest rates of total diabetes, undiagnosed diabetes, prediabetes, and suboptimal preconception glycemic control were found among non-Hispanic black women. In Aim 2, our data supported the hypothesis that women with diabetes would be more likely to use no contraception than their normoglycemic peers. In Aim 3, we found support for the hypothesis that women with diabetes who had a greater perception of contraception's benefits had greater odds of using procedure/prescription contraception in the postpartum period.

Together, the findings from the three papers in this dissertation identified priority populations and promising targets for future intervention development to improve family planning service delivery to women with diabetes.

I dedicate this work to my family.

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PREFACE

Chapter 2 has been published in the Journal of Women's Health, and copyright permission was granted for use of a pre-copyedited version of the article in this dissertation. Chapter 3 was published in the Journal of Midwifery & Women's Health, and based on the copyright agreement with the journal, a complete citation to the published article in the dissertation is sufficient to provide attribution to the published journal article. Citations are provided in the footnotes of Chapters 2 and 3.

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LIST OF ABBREVIATIONS

A1C	Glycated hemoglobin
ACE-inhibitors	Angiotensin converting enzyme inhibitors
ADA	American Diabetes Association
Add Health	National Longitudinal Study of Adolescent to Adult Health
ARBs	Angiotensin II receptor blockers
BRFSS	Behavioral Risk Factor Surveillance System
CDC	Centers for Disease Control and Prevention
CI	Confidence interval
DMPA	Depot medroxyprogesterone acetate
HIV	Human immunodeficiency virus
NICHD	National Institute of Child Health and Human Development
NHANES	National Health and Nutrition Examination Survey
NSFG	National Survey of Family Growth
PRAMS	Pregnancy Risk Assessment Monitoring System
OR	Odds ratio
RHAB	Reproductive Health Attitudes and Behaviors
RR	Risk ratio

RRR	Relative risk ratio
SEP	Socioeconomic position
T1DM	Type 1 diabetes mellitus
T2DM	Type 2 diabetes mellitus
UNC	University of North Carolina at Chapel Hill
U.S.	United States

CHAPTER 1: INTRODUCTION

Introduction

This three-manuscript dissertation contains five chapters. The first chapter is the introduction. The second, third, and fourth chapters are original, data-based manuscripts which each address a different aim. The Aim 1 manuscript (second chapter) was accepted by the Journal of Women's Health and described the prevalence of diabetes (including diagnosed diabetes, undiagnosed diabetes, poorly managed diabetes, and prediabetes) by race and ethnicity among women of reproductive age. The Aim 2 manuscript (third chapter) was accepted by the Journal of Midwifery & Women's Health and evaluated the relationship that contraceptive use had with diabetes status, diagnosis status, and glycemic control. The Aim 3 manuscript (fourth chapter) will be submitted to Journal of Obstetric, Gynecologic and Neonatal Nursing in January 2019 and will contain the findings of a survey describing contraceptive behaviors and attitudes of postpartum women with pre-pregnancy diabetes. The fifth chapter is a synthesis of the three data-based chapters.

Background and Significance of the Problem

More than 30 million Americans have diabetes (herein, "diabetes" refers to both type 1 diabetes mellitus (T1DM) or type 2 diabetes mellitus (T2DM) but not gestational diabetes (GDM)) of which 76% is diagnosed and 24% is undiagnosed (Centers for Disease Control and Prevention (CDC), 2017). Diabetes prevalence has increased more rapidly than was predicted: in 2001, diabetes prevalence was projected to reach 29 million by 2050, but 30 million was surpassed in 2017 (Boyle et al., 2001). Demographic shifts among the population with diabetes are also emerging: the average age of T2DM onset is decreasing as obesity increases (Cheng et al., 2013) and approximately 35% of newly diagnosed cases of diabetes are between 18 and 50 years of age (CDC, 2015). Recent estimates using data from a 2013 national sample are that 19% of women in the United States (U.S.) ages 15 to 50 years of age have some evidence of either prediabetes or diabetes (Marcinkevage et al., 2013).

Among women giving birth, the prevalence of diabetes established before pregnancy has increased from 8.6 per 1,000 hospital deliveries in 2005−2006 to 10.3 in 2013−2014 ($p < 0.001$) (Admon et al., 2017). Diabetes can cause numerous complications during pregnancy, particularly when blood glucose is elevated. Women with diabetes are at elevated risk of perinatal loss (Macintosh, 2006; Tennant, Glinianaia, Bilous, Rankin, & Bell, 2014). Compared to a national population in England, women with T1DM and T2DM had higher rates of stillbirth (26.8 vs 5.7 per 1,000 live births and stillbirths, relative risk (RR) 4.7, 95% confidence interval (CI) 3.7−6.0), perinatal death (31.8 vs 8.5 per 1,000 live births and stillbirths, RR 3.8, 95% CI 3.0−4.7), and neonatal death (9.3 vs 3.6 per 1,000 live births, RR 2.6, 95% CI 1.7−3.9) (Macintosh, 2006). In the Northern Diabetes in Pregnancy Survey in the British Isles, women with diabetes had 3.59 times the relative risk of fetal or infant death (including late miscarriage, stillbirth, neonatal death, and post-neonatal death) (95% CI 2.77−4.65) compared to women without diabetes (Tennant et al., 2014).

Diabetes is also associated with an elevated risk of fetal malformation (Correa et al., 2008; Feig et al., 2014; Macintosh, 2006). Women with diabetes had a 1.86 RR of congenital abnormalities (95% CI 1.49–2.33) compared to women without diabetes in a Canadian population-based cohort study (Feig et al., 2014). In the National Birth Defects Prevention Study, a multi-center case-control study, women with diabetes who had live births had elevated odds of having an infant with an isolated non-cardiac birth defect (odds ratio (OR) 2.34, 95% CI 1.44–3.81), multiple defects including a non-cardiac defect (OR 7.8, 95% CI 4.66–13.05), isolated cardiac defects (OR 4.64, 95% CI 2.87–7.51), and multiple defects including a cardiac defect (OR 10.77, 95% CI 6.23–18.62) (Correa, Bardenheier, Elixhauser, Geiss, & Gregg, 2014). In a British study, women with diabetes had 46 malformations per 1,000 births, significantly higher than the rate of 21 per 1,000 births in the national population (prevalence ratio 2.2, 95% CI 1.8–2.6) (Macintosh, 2006). It should be noted that the teratogenic effects of elevated blood glucose on organ formation occur in the embryonic period before GDM presents (American Diabetes Association (ADA), 2018).

Additionally, women with diabetes are at elevated risk of preeclampsia, preterm birth, cesarean section, maternal mortality, and long-term metabolic consequences in the life of the child (Evers, 2004; Hiilesmaa, Suhonen, & Teramo, 2000). In a Dutch prospective cohort study, compared to the national population, women with T1DM had higher rates of preeclampsia (12.7% vs. 1.05%, RR 12.1%, 95% CI 9.0−16.1), prematurity (32.2% vs 7.1%, RR 4.5, 95% CI 3.8−5.3), cesarean section (44.3%-12.0%, RR 3.7, 95% CI 3.2−4.2), and maternal mortality (0.6% vs 0.01%, RR 60.0, 95% CI 14.3−249.6) (Evers, 2004). Higher rates of preeclampsia have been observed among women with T1DM than without (12.8% vs 2.7%, OR 5.2; 95 % CI 3.3–8.4) (Hiilesmaa et al., 2000). Women with pregnancy diabetes have long been observed to have macrosomic infants, with 4.1 times the adjusted odds of delivering a large for gestational age infant to a woman with diabetes than without diabetes (95% CI 2.8-5.9) (Ehrenberg, Mercer, & Catalano, 2004). Cesarean section was more common among women with diabetes than without (34.9% vs 9.3%, OR 5.23, 95% CI 5.23 - 7.69) (Ehrenberg et al., 2004). For women with diabetes, macrosomic infants were more likely than non-macrosomic infants to experience shoulder dystocia (27.4% vs 4.7%, RR 5.8, 95% CI 2.3 to 14.7) and neonatal hypoglycemia (75.4% vs 54.5%, RR 1.4, 95% CI 1.2 -1.6) (Evers, 2004). There is also growing evidence that exposure to maternal T2DM in utero increases the likelihood of fetal programming for T2DM and obesity later in life (Berry, Boggess, & Johnson, 2016; Portha, Chavey, & Movassat, 2011).

Among women with diabetes, those with elevated glycated hemoglobin (A1C) have worse obstetrical outcomes than those with a lower A1C (Timar et al., 2014). Among Romanian women with T1DM, the adjusted odds of adverse pregnancy outcomes (including fetal loss, spontaneous abortion, and congenital malformations) were 2.78 times greater with every additional percentage point increase in A1C (95% CI 1.4-5.45) (Timar et al., 2014). Tennant et al. found a smaller effect: the odds of fetal and infant death increased by 1.02 for women with diabetes whose A1C exceeded 6.6% compared to those with an A1C below 6.6% (95% CI 1.04-4.05) (Tennant et al., 2014). In a Spanish prospective cohort study, women with diabetes who had A1C greater than 7.0% early in pregnancy had 5.1 the odds of a pregnancy loss (95% CI 1.4–17.1) than women with an A1C below 7.0% (Galindo, Burguillo, Azriel, & De La Fuente, 2006). The adjusted odds of preeclampsia were 1.6 times higher (95% CI 1.3–2.0) for each additional percentage point of A1C in the first trimester (Hiilesmaa et al., 2000).

The evidence is not conclusive about whether women with T1DM and T2DM are at different risk for adverse obstetrical outcomes after controlling for glycemic control, vascular damage, and body mass index (BMI). Tennant found that the risks of fetal or infant death were not different between British women with T1DM and T2DM, and that the type of diabetes did not modify the associations of fetal or infant death with A1C, history of retinopathy, or folic acid consumption (Tennant et al., 2014). At a Polish academic reference center for diabetes care, women with T1DM and T2DM were found to have similar proportions of miscarriages (10.0% vs 7.3%, $p = 0.32$), congenital malformation (7.9% vs 6.6%, $p = 0.78$), preterm deliveries (12.7% vs 17.8%, $p = 0.32$), caesarean sections (58.7% vs 64.1%, $p = 0.3$), and infant death (1.6% vs 2.2%, $p = 0.99$) (Cyganek et al., 2011). Since the current evidence suggests that elevated blood glucose in pregnancy has similar consequences in women with T1DM and T2DM, they were examined as one group.

A growing body of evidence suggests that women with diabetes can reduce the risks of adverse pregnancy outcomes through preconception care, although a recent Cochrane review concluded that the ideal regimen has not yet been identified (Tieu, Middleton, Crowther, & Shepherd, 2017). Establishing glycemic control is a central tenet of preconception care. The ADA also recommends rubella, syphilis, hepatitis B virus, and human immunodeficiency virus (HIV) testing; a pap smear; blood typing; initiating prenatal vitamins with at least 400 mg of folic acid; smoking cessation; testing including A1C, thyroid-stimulating hormone, creatinine, and urinary albumin-to-creatinine ratio; transitioning off teratogenic medications (including angiotensin-converting enzyme inhibitors (ACE inhibitors), angiotensin II receptor blockers (ARBs), and statins), and completing a comprehensive eye exam (ADA, 2018). Choosing to enter a preconception diabetes management program was associated with a significantly lower A1C in the first trimester (5.7% planning vs 6.4% not planning, $p = 0.02$) (Cyganek et al., 2011). The Atlantic Diabetes in Pregnancy Program, which incorporates preconception and prenatal care, reduced the rate of congenital malformations from 5.0% to 1.8% ($p = 0.04$) and stillbirths from 2.3% to 0.4% ($p = 0.06$) (Owens, Egan, Carmody, & Dunne, 2016). Among

Romanian women with T1DM, the adjusted odds of adverse pregnancy outcomes were 0.19 times lower if the pregnancy was planned (95% CI 0.048−0.75) (Timar et al., 2014). In a meta-analysis of preconception care programs, Wahabi et al. calculated that preconception care reduced the risk of preterm delivery by 0.70 (95% CI 0.55−0.90), birth defects by 0.25 (95% CI 0.25−0.42), and perinatal mortality by 0.35 (95% 0.15−0.82) (Wahabi, Alzeidan, Bawazeer, Alansari, & Esmaeil, 2010; Wahabi, Alzeidan, & Esmaeil, 2012).

Diabetes is one of the most expensive diseases in the U.S to manage, with an estimated $101.4 billion in diabetes-related healthcare expenditures spent annually by adults, of which $11 billion was spent by people aged 20-45 years (Dieleman et al., 2016). However, those estimations exclude costs of care for infants born to mothers with diabetes (personal communication, Dieleman, 2017). Using the effect sizes calculated by Wahabi et al. (Wahabi et al., 2010), Peterson et al. estimated that universal preconception care to all women with diabetes could prevent 10,664 preterm deliveries, 4,731 birth defects, and 2,377 cases of perinatal mortality, representing $953 million in medical costs and $4.5 billion in lost productivity in the U.S. annually (Peterson et al., 2015).

It is worth noting that the ideal preconception A1C has not always been 6.5% or less. Between the 2015 and 2016 Standards of Care, the ADA lowered their recommendation for preconception A1C from 7.0% to 6.5% (ADA, 2015; Bailey et al., 2015). In 2004, Evers et al. noted that the preconception target of A1C < 7.0% was associated with concerning rates of neonatal morbidity and suggested the need for the threshold for “good” glycemic control in pregnancy (Evers, 2004). Having lowered the target, the ADA maintains the caveat that 6.5% is only appropriate if women can achieve it without hypoglycemia (ADA, 2018) as some evidence suggests that hypoglycemia also increases the risk of congenital anomalies

(Tennant et al., 2014). Adequate preconception glycemic control, for the purpose of this dissertation, was operationalized as an A1C < 6.5%.

Racial and Ethnic Disparities in Diabetes Management

In this dissertation, I tested the hypotheses that the prevalence of diabetes and adequate preconception glycemic control differed by race and ethnicity as well as socioeconomic position (SEP) among women of reproductive age. These hypothesis were based on patterns in diabetes morbidity and mortality through adulthood (Ali et al., 2012; Barker, Kirtland, Gregg, Geiss, & Thompson, 2011; Brown et al., 2004; Casagrande, Fradkin, Saydah, Rust, & Cowie, 2013; A. Collier, Ghosh, Hair, & Waugh, 2015; Geiss et al., 2014; Lanting, Joung, Mackenbach, Lamberts, & Bootsma, 2005; Rawshani et al., 2015; Saydah, Imperatore, & Beckles, 2012). In an analysis of the 2011-2014 National Health and Nutrition Examination Survey (NHANES), the age-adjusted prevalence of diabetes was 9.3% for non-Hispanic white adults (95% CI 8.4−10.2), 16.0% for Asian adults (95% CI 13.6−18.9), 16.4% for Hispanic adults (95% CI 14.1−18.9), and 17.7% for non-Hispanic black adults (95% CI 15.8−19.9); while the CDC did not perform any hypothesis testing, a significant difference between non-Hispanic white adults and the other three groups was suggested by the lack of overlap in 95% confidence intervals (CDC, 2017). In the contiguous Southeastern U.S., counties with the highest rates of diabetes (dubbed the “diabetes belt” if diabetes prevalence exceeded 11%), non-Hispanic black adults had a 1.5 adjusted odds of having diagnosed diabetes (95% CI 1.4−1.6) while in the rest of the U.S., their odds were 1.9 times greater than those of non-Hispanic white adults (95% CI 1.8−2.0) (Barker et al., 2011). In addition to having higher diabetes prevalence, non-Hispanic black and Hispanic adults have had a more rapid increase in diabetes incidence than non-Hispanic white adults (Geiss et al., 2014).

Racial and ethnic differences in glycemic control have also been noted in adults with diabetes (Ali et al., 2012; Okosun, Annor, Dawodu, & Eriksen, 2018). In 2005-2006, 2007-2008, and 2009-2010 NHANES, A1C was greater than 7.0% for significantly more non-Hispanic black adults with diabetes than non-Hispanic white adults with diabetes (30.3% vs 18.9%), (Okosun et al., 2018). Similarly, 17.6% of non-Hispanic black adults and 16.2% of Hispanic adults with diabetes had an A1C > 9.0%, in comparison to 9.7% of non-Hispanic white adults ($p < 0.05$) (Ali et al., 2012).

SEP may complicate the relationship between diabetes outcomes and race and ethnicity. A review found that non-Hispanic black and Hispanic adults disproportionately experienced the complications of diabetes, including end-stage renal disease, lower limb amputation, and retinopathy, though the studies were inconsistent about whether the associations remained after adjustments, including various measures of SEP (Lanting et al., 2005). Robbins et al. found that poverty-income ratio attenuated some of the effects of the non-Hispanic black race for women, such that the age-adjusted odds ratio of diabetes were reduced from 1.76 (95% 1.21−2.57) to non-significance (aOR 1.43, 95% CI 0.95−2.13) (Robbins, Vaccarino, Zhang, & Kasl, 2000). A relationship between SEP and diabetes has been described in an analysis of U.S. adults over age 24 years with diabetes, where higher prevalence of functional limitations, self-rated poor or fair health, or lacking health insurance was more common among those with less education than more; among those without wealth than with wealth (represented by ownership of stocks or a home); or among those with a lower income-poverty ratio than a higher ratio (Saydah, Imperatore, & Beckles, 2013). In

Saydah et al.'s (2013) final proportional hazard model (which included demographic variables, healthcare and utilization variables, and psychosocial distress variables as well as the SEP variables), lacking a high school diploma (hazard ratio (HR) 1.52, 95% 1.04−2.23) and lacking wealth (HR 1.56, 95% CI 1.07−2.27) were significant predictors of all-cause mortality among adults over age 24 years with diabetes. The relationship between poor diabetes outcomes and lower socioeconomic position (SEP) even persisted in multiple national contexts with more robust social welfare programs, including the United Kingdom (A. Collier et al., 2015) and Sweden (Rawshani et al., 2015).

Theoretical Frameworks

Two convergent theoretical frameworks guided this study: Pender's Revised Health Promotion Model (Pender, 2011) and Socioeconomic Position and Health among Persons with Diabetes Mellitus (Brown et al., 2004). The Socioeconomic Position and Health among Persons with Diabetes Mellitus conceptual framework explicates the potential mechanisms by which race and ethnicity and SEP affect the health outcomes of adults with diabetes (Brown et al., 2004). In Brown et al.'s model, race and ethnicity both directly and indirectly influence health outcomes (including mortality, morbidity, quality of life, preventable hospitalizations, and emergency department utilization) (2004). SEP was as a mediator of other proximal mediators and moderators of health through health behaviors such as blood glucose monitoring, adherence to a recommended diet, and exercise; access, including primary care provider visits, specialty visits, and waiting times; and process, including obtaining measurements of A1C, cholesterol, foot health, retinopathy, and nephropathy status (Brown et al., 2004). For this study, use of highly effective contraception by women with diabetes when not seeking pregnancy was conceptualized as the preventative health behavior of interest and antecedents were based on Brown et al.'s framework (2004).

Data about family planning behaviors in the general population justified querying race and ethnicity, in addition to SEP, as direct antecedents of contraception use by women with diabetes. In the combined 2002 and 2006-2010 National Survey of Family Growth (NSFG), non-Hispanic black women who were born in the U.S. had 1.5 times the adjusted odds of not using contraception than non-Hispanic white women (95% CI 1.18−1.89), while foreign-born non-Hispanic black women had 2.4 times the odds (aOR 1.46−4.03) and Hispanic women were not significantly different (aOR 1.0, 95% CI 0.85−1.29) (Mosher, Jones, & Abma, 2015). In the 2006-2010 NSFG, the odds of using highly effective or moderately effective contraception, rather than less effective contraception, were lower for non-Hispanic black women (aOR 0.49, 95% CI 0.37−0.65) and Hispanic women (aOR 0.57, 95% CI 0.43−0.76) in comparison to non-Hispanic white women (Dehlendorf et al., 2014). Financial barriers prevented many women from using the most effective contraception they desired (Madden, Secura, Nease, Politi, & Peipert, 2015). The unintended pregnancy rate was higher among women with less education than more (73 per 1,000 women without a high school diploma vs. 25 per 1,000 women with some college or an associate's degree), among women in poverty than those who were not (112 per 1,000 women < 100% poverty level vs 20 per 1,000 women ≥ 200% of the poverty level), and among minority women (79 per 1,000 non-Hispanic black women vs 58 per 1,000 Hispanic women vs 33 per 1,000 non-Hispanic white women) (Finer & Zolna, 2016).

Similar racial and ethnic and SEP differences were seen in the number of deliveries affected by preconception diabetes: between 2000-2010, the age-standardized absolute change was 0.26 per 100 births for non-Hispanic black women, 0.20 for Hispanic women, and 0.16 for non-Hispanic white women, resulting in respective rates of 1.27, 0.94, and 0.72 deliveries to women with preconception diabetes per 100 births (Bardenheier et al., 2015). Using the National Inpatient Sample 2009, significantly higher rates of hospital deliveries to women with preconception diabetes were seen among women with Medicaid/Medicare (1.26 per 100 deliveries, 95% CI 1.14-1.40) than private insurance (0.73 per 100 deliveries, 95% CI 0.68-0.79), as well as among women who live in a ZIP code where the median income is below $39,000 (1.26 per 100 deliveries, 95% CI 0.15-1.37) than above $39,000 (0.80 per 100 deliveries, 95% CI 0.74-0.88) (Correa et al., 2015). Since there appear to be disparities in diabetes outcomes and family planning outcomes, we were motivated to examine the intersection of these issues through the lens of Brown et al.'s (2004) theoretical model.

To establish a foundation for future patient-centered intervention development, Pender's Revised Health Promotion Model was also incorporated in the study (Pender, 2011). Pender's (2011) model, like Brown et al.'s (2004), provides a conceptual framework to understand how health beliefs can precede health behaviors influencing health outcomes. A "reciprocal interaction worldview" underpins the Pender's model, positing that people are in constant interaction with a context, which can be understood more deeply through Brown et al.'s model, which suggests the mechanisms underlying the reciprocal relationship between individual experiences and the environment co-occurring with health beliefs driving health behaviors (Brown et al., 2004; Pender, 2011). Brown et al.'s Socioeconomic Position and Health among Persons with Diabetes Mellitus (Brown et al., 2004) and Pender's Revised Health Promotion Model (Pender, 2011) were synthesized into a linked theoretical framework (Figure 1). Together, these models provide an innovative lens for examining how race and ethnicity, SEP, and attitudes function as antecedents to contraception use among women with diabetes.

In this dissertation study, the Revised Health Promotion Model constructs measured were perceived benefits of action (perceptions of the positive or reinforcing consequences of undertaking a health behavior), perceived barriers to action (perceptions of the blocks, hurdles, and personal costs of undertaking a health behavior), and perceived self-efficacy (judgment of personal capability to organize and execute a particular health behavior; self-confidence in performing the health behavior successfully) preceding contraception non-use by women with diabetes not seeking pregnancy (Pender, 2011). Perceived benefit motivates a health behavior, while perceived barriers constrain action (Pender, 2011). Perceived self-efficacy is associated with increased health behaviors, both directly and indirectly by decreasing perceived barriers (Pender, 2011). By modeling attitudes that precede contraception non-use, this study identified targets which could be modified through nursing interventions for the populations considered as most in need.

Study Aims

Aim 1 is to estimate the prevalence of diagnosed diabetes, undiagnosed diabetes, suboptimal preconception glycemic control, and prediabetes among women of reproductive age by race and ethnicity. Aim 2 is to distinguish the effectiveness of contraception used by women with diagnosed diabetes, undiagnosed diabetes, and prediabetes and evaluate the hypothesis that women with diabetes used less effective contraception than women without diabetes. Aim 3 is to describe the attitudes of women with diabetes towards using contraception (including cognitive and affective orientation towards barriers to, benefits of, and self-efficacy about contraception use).

Methods

Aims 1 and 2 were addressed with a correlation design using Add Health data collected 2007−2008 in Wave IV (Harris, 2013). The Add Health study was initiated in 1994 in response to a mandate from the U.S. Congress to increase research about factors that influence health through adolescence and young adulthood. Add Health is funded by the National Institute of Child Health and Human Development (NICHD) with co-funding from 23 other federal agencies and foundations (P01 HD031921) (Carolina Population Center, 2017). The sample was based on a stratified, school-based cluster sampling strategy representative of high schools on the region, rurality, urbanity, school size, school type, and ethnic composition in the U.S. (Harris et al., 2009). All high schools with over 30 students were identified, and 80 were chosen for Add Health. Each high school was paired with one of 52 feeder middle schools. After stratification within schools by grade and gender, 200 students were randomly selected from each school pair. Thus, the sample is nationally representative of people who were 7^{th}-12^{th} graders in 1994−1995 school year in the U.S. The longitudinal cohort included high school dropouts. Upon evaluation, no evidence was found for significant non-response bias, a common concern of longitudinal cohort studies (Brownstein et al., 2011). Racial and ethnic minorities were purposefully oversampled, and complex weighting was required to achieve generalizable results. In 1994−1995, Wave I captured 20,745 participants from ages 11-19 (79% response rate) (Carolina Population Center, n.d.). In 2007−2008, Wave IV re-surveyed 15,701 participants when they were ages 24-32 years old (80.3% response rate). All variables of interest were collected at Wave IV in 2007-2008 except race and ethnicity, which were collected in 1994−1995 in Wave I.

For Aim 1, the sample for this analysis was composed of self-identified non-pregnant women who completed the survey at both Waves I and IV with data for all study variables (n = 6,774). Women who reported that they were pregnant at Wave IV were excluded because the preconception glycemic targets are different than those during pregnancy, which can have an independent physiological impact of insulin requirement, insulin sensitivity, and blood glucose levels (ADA, 2018). For the Aim 2 analysis, inclusion was additionally restricted to non-pregnant women who reported sexual activity with men in the last year (n = 5,448). Additionally, in Aim 2, BMI was added as a covariate in the model because of potentially confounding relationship with contraceptive method (Chuang, Chase, Bensyl, & Weisman, 2005).

For Aim 3, primary survey data was collected between 4−8 weeks postpartum from women with pre-pregnancy diabetes. The 35-question survey was housed on Qualtrics. Women were able to access the survey on a study iPad provided in the clinic or by following a web link. Institutional Review Board (IRB) approval was obtained to recruit participants at the University of North Carolina Hospital High-Risk Obstetrics Clinic. Recruitment began in June 2017, initially for recruitment of women with T2DM between 6-8 weeks postpartum. Upon observing that women with diabetes often returned to the clinic for postpartum care before 6 weeks, an IRB modification was sought to collect data between 4−8 weeks postpartum. Another IRB modification was obtained to recruit women with T1DM as well, since most evidence indicated that elevated blood glucose was associated with adverse obstetrical outcomes in the same manner (ADA, 2018) and thus the clinical benefits of postpartum contraception use were the same. In the first six months, we failed to meet our recruitment goal, so we sought another IRB modification to permit contact using the telephone numbers and email addresses in the patient profile of the electronic medical records; obtain consent to participate between 37 weeks gestation and 4 weeks postpartum; and recruit from the High-Risk Obstetrics Clinic at UNC Rex Healthcare and Vilcom, satellites in the same healthcare system. The dissertation was completed with an analytic sample of 40 women. The goal is 90 women, and recruitment is ongoing.

The survey's primary outcome was postpartum contraception, which was queried with an investigator-developed item, and dichotomized as use of procedure or prescription method versus non-prescription or no method. The primary predictors were constructs in Pender's Revised Health Promotion Model, measured with three scales from the Reproductive Health Attitudes and Behaviors (RHAB) instrument: the perceived benefits of contraception use (4 items, Cronbach's $\alpha = 0.65$), perceived barriers to contraception use (5 items, Cronbach's $\alpha = 0.72$), and perceived self-efficacy concerning preconception care, which encompassed, "achieving normal blood sugars, obtaining preconception counseling, and using effective birth control" (6 items, Cronbach's $\alpha = 0.65$) (Charron-Prochownik, Wang, Sereika, Kim, & Janz, 2006). The RHAB was developed and validated among adolescent women with T1DM (Charron-Prochownik, Wang, Sereika, Kim, & Janz, 2006).

Participants were asked investigator-developed questions about their perception of whether diabetes caused complications in their recent pregnancy, whether diabetes influenced their choice of contraception, and their intentions for future pregnancies. Intendedness of the index pregnancy was measured with the London Measure of Unplanned Pregnancy (LMUP) (Barrett, Smith, & Wellings, 2004). The LMUP was originally validated in England (Barrett et al., 2004). After minor modifications, the LMUP was validated in the

U.S., with a Cronbach's alpha of 0.78, all item-total correlations were over 0.20, and had a weighted Kappa of 0.72 (Morof et al., 2012).

The main analysis was the association between postpartum contraception choice and, scores on the RHAB Barriers, Benefits, and Self-Efficacy Scales (Charron-Prochownik, Wang, Sereika, Kim, & Janz, 2006), controlling for pregnancy intendedness and other covariates. Assuming, as reported by Schwarz et al. (Schwarz, Maselli, & Gonzales, 2006), that approximately 30% used "strong" (procedure or prescription) and 70% use "weak or no" (non-prescription or no) contraception, a total sample of 90 postpartum mothers allowed for 80% power to detect a medium-large standardized mean difference of d = 0.65 between the two groups, in a two-tailed t-test with a significance level of 0.05. This was adequate power for initial study; though it was possible that the true effect would be smaller. In the χ^2 tests, assuming that the dichotomized outcome variable contained approximately half the subjects in each category, we had 80% power to detect odds ratios of 3.9.

Description of Each Manuscript

In the Aim 1 manuscript, racial and ethnic differences in the prevalence of total diabetes (which includes both diagnosed and undiagnosed diabetes), undiagnosed diabetes, suboptimal preconception glycemic control, and prediabetes were described. Non-Hispanic black women had significantly higher rates of total diabetes, undiagnosed diabetes, prediabetes, and suboptimal preconception glycemic control than non-Hispanic white women. In the Aim 2 manuscript, contraceptive use of women with diabetes was described and compared to women with prediabetes and normoglycemia. Women with diabetes had higher odds of using no contraception, rather than more effective contraception, compared to women with normoglycemia. In the Aim 3 manuscript, postpartum women with diabetes were surveyed about their postpartum contraceptive use and contraceptive attitude. Use of prescription contraceptive use was greater when women held the attitude that contraceptive use and preconception care were beneficial.

The Aim 1 manuscript, entitled “Racial/ethnic disparities in diabetes diagnosis and glycemic control among women of reproductive age,” described differences in the distribution of diabetes by sociodemographic characteristics (race and ethnicity, socioeconomic position, insurance status, and access to healthcare). This inquiry was motivated by the inconclusive findings about diabetes-related health disparities among our population of interest in the previously cited literature that utilizes the nationally representative NHANES dataset, which identifies diabetes with biomarkers but whose sample size is inadequate for stratification by age, gender, and race/ethnicity. Add Health was deemed a more appropriate nationally representative dataset for our research question because it contains a larger young adult sample while also identifying diabetes with a highly sensitive biomarker methodology (Nguyen et al., 2014). The sample for Aim 1 included 256 women with undiagnosed diabetes and 279 women with diagnosed diabetes (n = 535). In contrast, a recent NHANES analysis had only 30 women with undiagnosed diabetes and the authors demurred that the sample was too small to produce estimates of population percentages (Razzaghi, Marcinkevage, & Peterson, 2015).

In previous analyses of diabetes in Wave IV of Add Health, non-Hispanic black participants were significantly more likely than non-Hispanic white participants to have prediabetes or undiagnosed diabetes but not diagnosed diabetes, but the analysis was no stratified by gender (Bellatorre, 2014). The analysis in Aim 1 provided a more precise estimate of diabetes distribution among women of reproductive age and the disparate burden by race and ethnicity. Hypotheses were tested that the prevalence of diabetes, undiagnosed diabetes, and suboptimal preconception glycemic control varied by race and ethnicity and SEP.

The Aim 2 manuscript, entitled “Contraceptive use patterns among women with prediabetes and diabetes in a U.S. national sample,” described differences by diabetes status and glycemic control in the most effective contraceptive methods. Although the ADA encourages women to delay pregnancy with contraception until they have an A1C of 6.5% or lower if that can be achieved without hypoglycemia (ADA, 2018), evidence shows inconsistent contraception use and pregnancy planning by women with diabetes (Chuang et al., 2005; Klingensmith et al., 2016; Osman, Hoffman, Moore, & van der Spuy, 2015; Vahratian, Barber, Lawrence, & Kim, 2009; Varughese, Chowdhury, Warner, & Barton, 2007). When women with diabetes are aggregated with women with other chronic illnesses, unintended pregnancy and contraception non-use occurred as often or more than among healthy peers (Choquet, Du Pasquier Fediaevsky, & Manfredi, 1997; Falsetti et al., 2003; Scaramuzza et al., 2010; Suris, Resnick, Cassuto, & Blum, 1996; Suris & Parera, 2005; Suris, Michaud, Akre, & Sawyer, 2008).

The diabetes-specific data were dated, showed mixed results, often failed to distinguish between more and less effective contraception methods, and analyses were conducted on samples lacking biomarker data, without which prediabetes and undiagnosed diabetes status could not be identified. Vahratian and colleagues (2009) analyzed the nationally representative 2002 NSFG, in which women with diabetes were only identified by self-report, and found that 38.8% used no contraception (Vahratian et al., 2009). In an analysis of the 2000 Behavioral Risk Factor Surveillance System (BRFSS) from 11 states, Chuang et al. found 25.8% of women with self-reported diabetes did not use contraception; this analysis excluded women who were trying to become pregnant (Chuang et al., 2005). Both Chuang et al. and Vahratian et al. found that women with diabetes were no more likely to be contraception non-users than women without diabetes, after adjustments for confounders. However, the Aim 2 sample contained women with both diagnosed and undiagnosed diabetes and was able to describe the contraceptive use patterns of women with diabetes more comprehensively. The hypothesis was tested that women with diabetes use highly effective contraception less than women without diabetes.

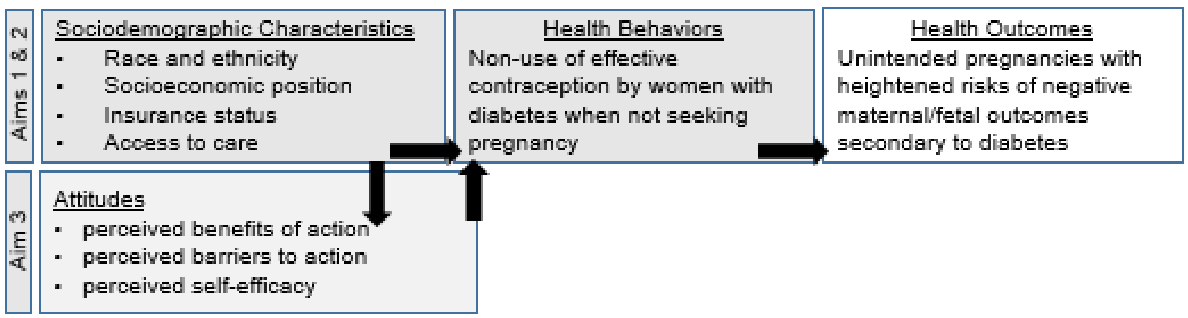
The Aim 3 manuscript, entitled "Contraceptive attitudes and behaviors of postpartum women with pre-pregnancy diabetes," described associations between postpartum contraceptive use and attitudes about contraception, pregnancy planning, and diabetes. Findings from Aim 3 advances older literature, which predominantly represented the views of white women with T1DM, in which modifiable reasons for not using preconception care and contraception to plan pregnancies included a lack of access to contraceptive counseling and resources, erroneous perceptions of infertility (Holing, Beyer, Brown, & Connell, 1998), knowledge deficits about the impact of diabetes on pregnancy (Chuang, Velott, & Weisman, 2010), or fears that contraception was unsafe or ineffective for women with diabetes (St. James, Younger, Hamilton, & Waisbren, 1993). Perspective of women with diabetes on postpartum contraceptive use, specifically, has not been well-described in the scientific literature. Contraception use in this period is critical to give a woman time to reestablish her health and well-being after the pregnancy, and can function as the potential preconception period for future pregnancies (ADA, 2018). We tested the hypotheses that use of a highly effective contraception postpartum was associated with higher perception of benefits, lower perception of barriers, and higher self-efficacy.

Conclusion

Because young adult women with diabetes are an emerging patient population, there were significant research gaps in the literature concerning their prevalence, disparities, contraceptive behaviors, and attitudes towards family planning. This dissertation has produced evidence which can direct future intervention development to the women who can benefit most. In particular, Aims 1 and 2 identify the strong need for improved family planning service delivery to women with diabetes, particularly those who are non-Hispanic black and Hispanic. Future work to improve family planning in the context of diabetes management has the potential to ameliorate some racial and ethnic disparities in pregnancy planning and outcomes. Aim 3 highlights that enhancing women's perception of contraceptive benefits may foster contraceptive use in the postpartum period. Emphasizing contraception's benefits for women with diabetes may help women to have healthier pregnancies when they want to expand their families.

Healthcare providers in family planning, primary care, and diabetes management can provide women with better support to avert unintended pregnancies complicated by elevated blood glucose. Supporting better integration of family planning and diabetes management has untapped potential to improve obstetrical outcomes, quality of life, and health equity.

Figure 1.1. Conceptual framework integrating Brown et al.'s "Socioeconomic Position and Health among Persons with Diabetes Mellitus" (2004) and Pender's "Revised Health Promotion Model" (2011).



CHAPTER 2: RACIAL/ETHNIC DISPARITIES IN DIABETES DIAGNOSIS AND GLYCEMIC CONTROL AMONG WOMEN OF REPRODUCTIVE AGE[1]

Introduction

More than 29 million Americans have diabetes, including 12–14% of adults over age 20, and the prevalence is projected to increase (Cheng et al., 2013; Menke, Casagrande, Geiss, & Cowie, 2015). Because the average age of diagnosis is declining, approximately one-third of new diagnoses now occur between ages 18 and 50, when most women can become pregnant (Centers for Disease Control and Prevention (CDC), 2015). Inadequately controlled diabetes in pregnancy is associated with fetal malformation, spontaneous abortion, stillbirth, preeclampsia, preterm birth, macrosomia, and fetal programming for obesity and diabetes later in life (Berry et al., 2016; Cyganek et al., 2011; Kinsley, 2007; Kitzmiller, Wallerstein, Correa, & Kwan, 2010; Lapolla, Dalfrà, & Fedele, 2008). To reduce diabetes-related risks during pregnancy, the American Diabetes Association (ADA) recommends that women strive to lower their blood glucose until they achieve glycated hemoglobin (A1C) below 6.5% by using preconception care as well as contraception to delay pregnancy until they are ready for pregnancy (ADA, 2018).Women whose diabetes is undiagnosed, by definition, have not been identified as appropriate candidates of the ADA's recommendations for care to improve glycemic control before pregnancy. Understanding the growing

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prevalence and distribution of diabetes diagnoses and elevated blood glucose among women of reproductive age is critical for targeting improved reproductive health service delivery, including both preconception care and family planning, in coordination with diabetes management.

In the United States (U.S.), diabetes morbidity disproportionately burdens people who are racial/ethnic minorities. Compared to non-Hispanic white adults, non-Hispanic black and Hispanic adults are more likely to have diabetes, elevated A1C and sequelae such as lower extremity amputation, retinopathy, and kidney failure (Agency for Healthcare Research and Quality, 2001; Casagrande et al., 2013; Geiss et al., 2014; Peek, Cargill, & Huang, 2007). Diabetes incidence has been increasing at faster rates among non-Hispanic black and Hispanic adults than non-Hispanic white adults (Geiss et al., 2014). Prevalence of pre-pregnancy diabetes has increased among women giving birth in hospitals (Correa et al., 2014). Among deliveries in hospitals in 19 states, the highest rates and highest absolute rate changes in pre-pregnancy diabetes occurred among non-Hispanic black and Hispanic women (Bardenheier et al., 2015). However, the prevalence of diabetes in nationally representative samples is rarely described with stratification by age, gender, and race/ethnicity in the manner necessary to understand trends in diabetes as a risk factor for adverse obstetrical outcomes. Thus, the objective of this study was to describe the distribution of pre-pregnancy diagnosed diabetes, undiagnosed diabetes, suboptimal preconception glycemic control, and prediabetes by race/ethnicity among women of reproductive age using a nationally representative U.S. sample.

Methods

Dataset

We analyzed data from the National Longitudinal Study of Adolescent to Adult Health (Add Health). Add Health used a stratified, school-based cluster sample representative of American high schools (Harris et al., 2009). Participants were recruited while in 7th–12th grade during the 1994–1995 school year (Wave I), and follow-up data were collected in 1996 (Wave II), 2001–2002 (Wave III), and 2007–2008 (Wave IV). Participants completed in-home interviews during each wave. During Wave IV, biological specimens were collected, and A1C was determined from capillary whole blood via finger prick, a valid and reliable test (Nguyen et al., 2014; Whitsel et al., 2012). A1C is a measurement of glycated hemoglobin which represents average blood glucose over the previous two to three months. A1C values between 5.7-6.4% indicate prediabetes, and A1C values of 6.5% and above indicate diabetes (ADA, 2018).

In all analyses, we applied sample weights to adjust for school-level clustering and unequal probability of selection in order to generate estimates that were nationally representative of Americans who were in 7th–12th grade during the 1994–1995 school year.

Primary Outcome: Diabetes Status

Women were categorized as having diabetes if they had a fasting glucose ≥ 126; a non-fasting glucose ≥ 200mg/dl; an A1C ≥ 6.5%; self-reported diabetes history (affirming they had a "history of being told by a doctor or health care professional that you have diabetes (if female, outside of pregnancy)"); or anti-hyperglycemic medication use, based on a prescription inventory of medications used in the preceding four weeks. Full details on the diabetes variables in Add Health have been described elsewhere (Whitsel et al., 2012). The blood-based criteria reflected the ADA clinical guidelines for diagnosis (ADA, 2018).

Among the women with diabetes, we characterized a woman as diagnosed if she had a self-reported diabetes history or anti-hyperglycemic medication use. Women were categorized as undiagnosed if they reported neither. Suboptimal preconception glycemic control in women with diabetes was defined as an A1C $\geq$ 6.5%, based on the ADA's preconception recommendations (ADA, 2018).

Women were considered to have prediabetes if they had an A1C of 5.7–6.4% and no evidence of diabetes based on self-reported history of diagnoses or anti-hyperglycemic medication use (ADA, 2018). Women without prediabetes or diabetes were categorized as normoglycemic.

Primary Predictor: Race/Ethnicity

The five mutually exclusive categories were created based on the respondent-identified Hispanic ethnicity and race during Wave I in 1994–1995 (Udry, Li, & Hendrickson-Smith, 2003) (non-Hispanic white; non-Hispanic black; Hispanic of any race; non-Hispanic Native American; and non-Hispanic Asian).

Covariates: Sociodemographic Characteristics

Additional covariates, all from Wave IV, included educational attainment, type of health insurance, and self-reported limited access to healthcare in the preceding 12 months. In young adulthood, education is generally stable and derived from a single source, unlike household income, which is more volatile and may include multiple people and multiple sources (Kawachi, Adler, & Dow, 2010; Preston & Taubman, 1994; Williams, Mohammed, Leavell, & Collins, 2010). Therefore, we used educational attainment as a proxy for socioeconomic position rather than income.

Statistical Analysis

We used provided survey weights to compute unbiased population estimates and implemented linearization to perform design-based standard error computations. We used the second order Rao-Scott design-adjusted F test to examine the null hypothesis of independence between diabetes status and sociodemographic characteristics.

For the primary analysis, race/ethnicity as a predictor of diabetes status was modeled with maximum-likelihood multinomial logit regression, with normoglycemia as the base outcome and non-Hispanic white women as the reference group. The adjusted model included sociodemographic characteristics (educational attainment, insurance, and access to healthcare). The null hypothesis was that there would be no racial/ethnic differences in the odds of a woman having diabetes or prediabetes rather than normoglycemia. Beta coefficients from the regression model were exponentiated to yield adjusted odds ratios (aORs). The overall significance of each predictor was examined with an adjusted Wald test.

Subclass analyses were conducted to explore racial/ethnic differences in glycemic control and diagnosis status among women with diabetes. We attempted to fit a linear model for A1C, but these models violated the usual regression assumptions of normality and homogeneity of the variance of the residuals. Consequently, we only reported on the logistic regression models with suboptimal preconception glycemic control. We fit an additional logistic regression model for being undiagnosed versus diagnosed.

All tests were two-tailed, with a 0.05 significance level. All analyses were completed in Stata version 14.1 (StataCorp LP), using the SVY commands to apply sampling weights.

Institutional review board approval was obtained from the University of North Carolina at Chapel Hill.

Results

We used data from 6,774 non-pregnant women aged 24–32 with complete covariate data. Of the 7,870 women who provided data at Wave IV and had sampling weights, we excluded women from this analysis for being pregnant (n = 519), or missing values for any of the following: pregnancy status (n = 48), insurance (n = 12), access to care (n = 1), ethnicity (n = 28), race (n = 149), or A1C (n = 551 due to refusals, ineligibility due to incarceration, or insufficient blood sample).

We estimated that 6.8% of women between ages 24-32 had diabetes and 21.8% had prediabetes. Table 2.1 shows the weighted estimates of population prevalence. The bivariate association between diabetes status and race/ethnicity was significant ($p < 0.001$). Diabetes was most prevalent among non-Hispanic black women (15.0%), followed by Native American (10.1%), Hispanic (7.5%), non-Hispanic white (4.8%), and Asian (4.5%) women. Non-Hispanic black women had the greatest proportion of prediabetes (38.5%), followed by Hispanic (27.8%), Asian (25.1%), Native American (20.4%), and non-Hispanic white (16.6%) women. Diabetes status had significant bivariate associations with education ($p < 0.001$), insurance ($p = 0.003$), and access to care ($p < 0.001$).

Of the women with diabetes, 45.3% were undiagnosed (Table 2.2). Being undiagnosed had a significant bivariate association with race/ethnicity ($p < 0.001$). The majority of non-Hispanic black women with diabetes were undiagnosed (75.6%), while less than half of the women with diabetes who were Hispanic (48.1%), non-Hispanic white (22.8%), or Asian (11.4%) were undiagnosed. The cell counts for Native American women with diabetes were too small to report per Add Health guidelines. Being undiagnosed did not have significant bivariate associations with education ($p = 0.29$), insurance ($p = 0.61$), or access to care ($p = 0.92$).

Approximately half (51.0%) of the women with diabetes had suboptimal preconception glycemic control (A1C $\geq$ 6.5%). Glycemic control had a significant bivariate association with race/ethnicity ($p < 0.001$) but not education ($p = 0.32$), insurance ($p = 0.11$), or access to care ($p = 0.07$). The majority of non-Hispanic black women with diabetes had an A1C $\geq$ 6.5% (88.2%), whereas smaller proportions of Hispanic (42.9%), non-Hispanic white (26.3%), and Asian (18.1%) women with diabetes had suboptimal preconception glycemic control.

Multinomial Analysis

Table 2.3 shows that race/ethnicity was a significant predictor of diabetes status in the adjusted multinomial logit model ($p < 0.001$). Relative to non-Hispanic white women, the odds of having prediabetes or diabetes rather than normoglycemia, even after adjusting for education, insurance, and access to care, were higher for non-Hispanic black women (diabetes: aOR = 4.8; prediabetes: aOR = 3.7) and Hispanic women (diabetes: aOR = 1.7; prediabetes: aOR = 1.9). Asian women had greater adjusted odds of having prediabetes instead of normoglycemia than non-Hispanic white women (aOR = 1.8). Education ($p < 0.001$) and access to care ($p = 0.04$) were significant predictors in the model, but insurance was not ($p = 0.93$).

Subclass Analysis

In the subclass analysis of women with diabetes (Table 2.4), non-Hispanic black women had 11.2 greater adjusted odds of being undiagnosed than non-Hispanic white women. Race/ethnicity was a significant predictor ($p < 0.001$) but education, insurance, and access to care were not.

Race/ethnicity was a significant predictor of suboptimal preconception glycemic control ($p < 0.001$). The adjusted odds of non-Hispanic black women having suboptimal preconception glycemic control of an A1C $\geq$ 6.5% were 15.6 greater than the odds for non-Hispanic white women. Diagnosis was also a significant predictor ($p = 0.002$): undiagnosed women had over three times the odds of A1C $\geq$ 6.5% than diagnosed women (aOR = 3.2). Education, insurance, and access to care were not significant predictors.

Discussion

Diabetes, undiagnosed diabetes, suboptimal preconception glycemic control, and prediabetes burdened women of reproductive age, and the burden varied by race/ethnicity. Alarmingly, more than half of non-Hispanic black women exhibited evidence of either prediabetes or diabetes. Early identification and effective management of diabetes are critical for supporting women in optimizing their health and having safe pregnancies, if and when they desire to bear children.

We estimate that 21.8% of women aged 24−32 had prediabetes, which more than doubles the odds of developing gestational diabetes, increasing risks of macrosomia, preeclampsia, and shoulder dystocia (ADA, 2018). An estimated 6.8% of women aged 24−32 had diabetes, of whom over half (51.0%) had suboptimal preconception glycemic control. Notably, 88.2% of non-Hispanic black women with diabetes exhibited A1C $\geq$ 6.5%. Women with diabetes can reduce the risks of adverse pregnancy outcomes, including fetal anomalies, preterm birth, and perinatal mortality, through preconception care, which includes lowering blood glucose, using contraception to time pregnancies, and other interventions (Ray, O'Brien, & Chan, 2001). Contraception use creates a window of time in which women may engage in preconception behaviors before trying to conceive. Our findings about diabetes prevalence among women of reproductive age highlight the importance of performing randomized clinical trials to identify the optimal preconception care protocol (Tieu et al., 2017).

We found a greater proportion of women aged 24-32 with diabetes to be undiagnosed (45.3%) than has been observed in the overall adult population (23.8%) (CDC, 2017). Lack of insurance and inadequate access to care, although not significant in our models, are well-documented barriers to diabetes screening (Zhang et al., 2008). However, under-detection also persists because of non-adherence to the ADA criteria for screening (Dall et al., 2014). The importance of adhering to screening criteria for people under age 45, before universal screening is recommended, is underscored by our findings that the majority (74.7%) of women aged 24-32 with undiagnosed diabetes had an A1C $\geq$ 6.5%.

We note several limitations. Wave IV of Add Health was collected before implementation of the Affordable Care Act; not capturing the impact of those policy changes, this analysis may serve as a point of comparison. Participants in Add Health were not asked if they had T1DM or T2DM, a limitation we deemed tolerable because, in both conditions, elevated blood glucose exerts the same physiological effect, particularly during organogenesis in the early weeks of pregnancy (ADA, 2018). While the Add Health sample was large enough to support stratification by both gender and race/ethnicity, the small cell counts for Native Americans should limit inferences about non-significant results, in light of other data about diabetes prevalence in those communities (Barnes, Adams, & Powell-Griner, 2010; Berry, Samos, Storti, & Grey, 2009; Denny, Floyd, Green, & Hayes, 2012).

Nonetheless, Add Health's large sample of young adult can address sample size limitation encountered with NHANES, the probability sample whose biomarker data is frequently used to generate population estimates about diabetes (Razzaghi et al., 2015).

We question how realistic it was that 49.0% of women with some evidence of diabetes had an A1C $< 6.5\%$ due to excellent glycemic management. It is possible that, instead, this sample includes measurement error resulting from women not correctly fasting before undergoing a fasting glucose test, self-reporting diabetes history incorrectly (i.e., reporting a history of gestational diabetes (GDM) despite being instructed to exclude those), or taking anti-hyperglycemic medications for other purposes (i.e., metformin for polycystic ovarian syndrome). To address this concern, we modeled having an A1C $\geq 6.5\%$ (Table 2.4). We found dramatically higher odds of non-Hispanic black women experiencing suboptimal preconception glycemic control than non-Hispanic white women.

Our findings should be contextualized in the larger body of evidence that Non-Hispanic black women and Hispanic women are disproportionately burdened by adverse obstetrical outcomes (Bryant, Worjoloh, Caughey, & Washington, 2010; Cubbin et al., 2002; MacDorman, 2011). We recommend that future research examine whether enhancing diabetes management in coordination with reproductive healthcare could be an innovative strategy for pursuing racial/ethnic equity in both women's health and infant health. Non-Hispanic black and Hispanic women with pre-pregnancy diabetes in the United States have identified numerous barriers to achieving glycemic control before, during, and after pregnancy: costs of supplies, medications, and nutritious food; challenges with maintaining diet and exercise regimens; and difficulties communicating with providers (S. A. Collier et al., 2011). To support women to optimize their health, we must center the voices of those most affected and address structural barriers to wellness.

In the U.S., there is a growing population of women of reproductive age with prediabetes and diabetes, many of whom are unaware that they are at heightened risk of, or already have, elevated blood glucose, threatening health during future pregnancies. Improving population health outcomes will require providers to address both the racial/ethnic disparities and potential reproductive health needs of young adult women managing diabetes.

Table 2.1. Sample characteristics and bivariate associations with diabetes status (n=6,774).

	Normoglycemia	**Prediabetes**	**Diabetes**	**Total**	**P[a]**
Total	4,641 (71.4%)	1,598 (21.8%)	535 (6.8%)	6,774 (100%)	
Sociodemographic characteristics					
Race/ethnicity					< 0.001
Non-Hispanic white	2,925 (78.6%)	613 (16.6%)	192 (4.8%)	3,730 (100%)	
Non-Hispanic black	752 (46.5%)	584 (38.5%)	222 (15.0%)	1,558 (100%)	
Hispanic	693 (64.7%)	273 (27.8%)	87 (7.5%)	1,053 (100%)	
Native American	26 (69.6%)	16 (20.4%)	8 (10.1%)	50 (100%)	
Asian	245 (70.4%)	112 (25.1%)	26 (4.5%)	383 (100%)	
Education					< 0.001
College graduate or more	1,749 (78.9%)	460 (16.8%)	118 (4.3%)	2,327 (100%)	
Some college or vocational school	2,021 (69.6%)	779 (23.2%)	276 (7.2%)	3,076 (100%)	
High school graduate	598 (63.0%)	242 (27.7%)	92 (9.3%)	932(100%)	
Less than high school	273 (65.8%)	117 (23.8%)	49 (10.4%)	439 (100%)	
Insurance					0.003
Private insurance	3,364 (73.4%)	1,099 (20.7%)	342 (6.0%)	4,805 (100%)	
Medicaid	444 (62.8%)	192 (26.9%)	84 (10.3%)	720 (100%)	
No insurance	833 (69.1%)	307 (23.2%)	109 (7.7%)	1,249 (100%)	
Access to Care					< 0.001
Had access	3,543 (72.9%)	1,177 (21.2%)	349 (5.9%)	5,069 (100%)	
Lacked access	1,098 (66.9%)	421 (23.8%)	186 (9.3%)	1,705 (100%)	

Unweighted n and weighted row percentages (may not add to 100.0% due to rounding).
[a]Bivariate associations tested with Rao-Scott design-adjusted F test.

Table 2.2. Diabetes subclass characteristics and bivariate associations with diagnosis status and glycemic control (n=535).

	Diagnosis Status			Glycemic Control		
	Undiagnosed	**Diagnosed**	**P[a]**	**A1C < 6.5%**	**A1C ≥ 6.5%**	**P[a]**
Total	256 (45.3%)	279 (54.7%)		225 (49.0%)	310 (51.0%)	
Sociodemographic characteristics						
Race/ethnicity			< 0.001			< 0.001
Non-Hispanic white	46 (22.8%)	146 (77.2%)		137 (73.7%)	55 (26.3%)	
Non-Hispanic black	162 (75.6%)	60 (24.4%)		34 (11.8%)	188 (88.2%)	
Hispanic	35 (48.1%)	52 (51.9%)		43 (57.1%)	44 (42.9%)	
Native American	‡	‡		‡	‡	
Asian	9 (11.4%)	17 (88.6%)		7 (81.9%)	19 (18.1%)	
Education			0.29			0.32
College graduate or more	58 (43.8%)	60 (56.2%)		57 (58.1%)	61 (41.9%)	
Some college or vocational school	134 (51.2%)	142 (48.8%)		115 (48.2%)	161 (51.8%)	
High school graduate	37 (39.2%)	55 (60.8%)		39 (49.1%)	53 (50.9%)	
Less than high school	27 (33.7%)	22 (66.3%)		14 (36.2%)	35 (63.8%)	
Insurance			0.61			0.11
Private insurance	162 (42.8%)	180 (57.2%)		155 (54.6%)	187 (45.4%)	
Medicaid	38 (50.8%)	46 (49.2%)		34 (44.7%)	50 (55.3%)	
No insurance	56 (47.7%)	53 (52.3%)		36 (36.8%)	73 (63.2%)	
Access to Care			0.92			0.07
Had access	173 (45.1%)	176 (54.9%)		151 (53.1%)	198 (46.9%)	
Lacked access	83 (45.7%)	103 (54.3%)		74 (41.4%)	112 (58.6%)	
Diagnosis						
Diagnosed	-	-	-	170 (68.5%)	109 (31.5%)	< 0.001
Undiagnosed	-	-	-	55 (25.3%)	201 (74.7%)	

Unweighted n and weighted row percentage (may not add to 100.0% due to rounding).
‡ cell count too small to publish per Add Health guidelines
[a]Bivariate associations tested with Rao-Scott design-adjusted F test

Table 2.3. Odds ratio estimates of diabetes status from multinomial logistic regression model (n=6,774).

	Prediabetes Vs. Normoglycemia aOR (95% CI)	Diabetes Vs. Normoglycemia aOR (95% CI)	P[a]
Race/ethnicity			< 0.001
Non-Hispanic white	Ref	Ref	
Non-Hispanic black	3.7 (3.0-4.5)***	4.8 (3.6-6.5)***	
Hispanic	1.9 (1.4-2.5)***	1.7 (1.2-2.5)**	
Native American	1.3 (0.3-5.1)	2.0 (0.5-8.3)	
Asian	1.8 (1.2-2.6)**	1.1 (0.3-3.8)	
Education			< 0.001
College graduate or more	Ref	Ref	
Some college or vocational school	1.4 (1.2-1.7)**	1.6 (1.1-2.2)**	
High school graduate	1.8 (1.4-2.5)***	2.2 (1.4-3.4)**	
Less than high school	1.4 (0.9-2.1)	2.2 (1.3-3.6)**	
Insurance			0.93
Private insurance	Ref	Ref	
Medicaid	1.1 (0.7-1.6)	1.2 (0.8-1.7)	
No insurance	1.0 (0.8-1.2)	1.0 (0.7-1.4)	
Access to Care			0.04
Had access	Ref	Ref	
Lacked access	1.1 (0.9-1.4)	1.5 (1.1-2.1)*	

aOR – adjusted odds ratio. CI – confidence interval. Base outcome is normoglycemia.
$* p < 0.05$, $** p < 0.01$, $*** p < 0.001$
[a] Adjusted Wald Test

Table 2.4. Odds ratio estimates of diagnosis status and glycemic control from logistic regression model among women with diabetes (n=535).

	Diagnosis Status[a] Undiagnosed diabetes		**Glycemic Control[b] A1C $\geq$ 6.5%**	
	aOR (95% CI)	**P[c]**	**aOR (95% CI)**	**P[c]**
Race/ethnicity		< 0.001		< 0.001
Non-Hispanic white	Ref		Ref	
Non-Hispanic black	11.2 (6.3, 19.9)***		15.6 (7.6, 32.2)***	
Hispanic	2.8 (1.0, 8.1)		1.9 (0.9, 4.0)	
Native American	‡		‡	
Asian	0.4 (0.1, 1.7)		1.2 (0.5, 2.7)	
Education		0.13		0.48
College graduate or more	Ref		Ref	
Some college or vocational school	1.0 (0.5, 1.9)		1.3 (0.6, 2.7)	
High school graduate	0.7 (0.3, 1.8)		1.8 (0.6, 5.0)	
Less than high school	0.3 (0.1, 0.9)*		2.3 (0.7, 7.6)	
Insurance		0.36		0.31
Private insurance	Ref		Ref	
Medicaid	1.6 (0.7, 3.4)		1.0 (0.4, 2.4)	
No insurance	1.5 (0.7, 3.2)		1.9 (0.8, 4.9)	
Access to Care		0.81		0.13
Had access	Ref		Ref	
Lacked access	1.1 (0.6, 1.9)		1.7 (0.9, 3.2)	
Diagnosis Status	NA			0.002
Diagnosed			Ref	
Undiagnosed			3.2 (1.8, 5.8)***	

aOR – adjusted odds ratio. CI – confidence interval.

‡ cell count too small to publish per Add Health guidelines
[a]Reference category is being diagnosed (self-reported diabetes history or anti-hyperglycemic medication use)
[b]Reference category is A1c < 6.5%
[c] Adjusted Wald Test
** p < 0.05, ** p < 0.01, *** p < 0.001*

CHAPTER 3: CONTRACEPTIVE USE AMONG WOMEN WITH PREDIABETES AND DIABETES IN A U.S. NATIONAL SAMPLE[2]

Introduction

A growing population of women has diabetes during their reproductive years (Britton, Hussey, Crandell, et al., 2018). Approximately 35% of newly diagnosed cases of diabetes occur between the ages of 18 and 50, and an estimated 19% of reproductive age women are not normoglycemic (Centers for Disease Control and Prevention (CDC), 2015; Marcinkevage et al., 2013). They need the reproductive care, tailored to their childbearing goals, that minimizes the harmful impact of elevated blood glucose during pregnancy. During pregnancy, elevated blood glucose secondary to poorly managed diabetes can lead to fetal malformation, pregnancy loss, preterm birth, preeclampsia, macrosomia, and fetal programming that increases the infant's risk of obesity and diabetes later in life (Berry et al., 2016; Correa et al., 2008; Cyganek et al., 2011; Portha et al., 2011). Currently, the American Diabetes Association (ADA) recommends that women with diabetes use contraception while engaging in preconception care to lower glycated hemoglobin (A1C) below 6.5% before pregnancy (ADA, 2018). However, as a patient population, women with diagnosed diabetes inconsistently receive contraception counseling, use contraception, plan pregnancies, or obtain preconception care, a finding that may be confounded by socioeconomic status or

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body mass index (BMI) (Champaloux et al., 2015; Chuang et al., 2005; Klingensmith et al., 2016; Osman et al., 2015; Schwarz et al., 2012; Vahratian et al., 2009; Varughese et al., 2007).

Using contraception to time pregnancies during periods of better glycemic control can help women with diabetes achieve their childbearing goals while reducing adverse pregnancy outcomes. The patterns of contraceptive use among women whose diabetes is undiagnosed or poorly managed have not been described using nationally representative data. Thus, the objectives of this study were to estimate the relationship between contraceptive use and key measures of glucose dysregulation, including prediabetes, undiagnosed diabetes, diagnosed diabetes, and suboptimal preconception glycemic control, among women of reproductive age in a U.S. national sample. We hypothesized that women with diabetes would be less likely to use contraception than their normoglycemic peers, controlling for demographic characteristics and body mass index (BMI).

Methods

We used data from the 2007–2009 Wave IV of the National Longitudinal Study of Adolescent to Adult Health (Add Health). Ninety-eight percent of participants were interviewed in 2008. Add Health used a stratified, school-based cluster sampling strategy and is representative of U.S. adults who were seventh to twelfth grade students during the 1994–1995 school year (Harris et al., 2009). Race/ethnicity was collected from in-home interviews at initial enrollment in 1994–1995. All other survey and biological data were collected from the same participants at follow-up home visits from 2007 to 2009. The informed consent process has been described elsewhere (Harris et al., 2009).

All self-identified non-pregnant female respondents who reported sexual activity with a male partner in the past year were eligible for this analysis. Women were excluded for missing values, refusals, or uncertain responses for demographic characteristics (n = 40), BMI (n = 100), contraceptive use (n = 20), or A1C (n = 457). The final, unweighted analytic sample contained 5,548 women.

The primary outcome was the most effective contraceptive method used in the prior 12 months. Participants were asked to indicate all types of contraceptive use in the prior 12 months, and categorized as using no contraception, less effective contraception, or more effective contraception (Table 3.1). Categorization reflects the widely used World Health Organization's Model of Tiered Contraceptive Effectiveness (Stanback, Steiner, Dorflinger, Solo, & Cates, 2015). Using the wording from the survey, we defined more effective methods to include tubal ligation/sterilization; vasectomy; IUD (intrauterine device), coil, loop; emergency IUD insertion; Norplant; birth control pills; Patch (Ortho Evra); ring (NuvaRing); and shot (Depo-Provera*)*. Less effective methods included condoms (rubbers); female condom; diaphragm, cap or shield; natural family planning (safe periods by temperature, cervical mucus test); rhythm or safe period by calendar; emergency contraception or "morning after" pill; withdrawal (pulling out); vaginal sponge; contraceptive film; and spermicide foam, jelly, creme, suppositories). For our analyses, women were categorized by the most effective method reported (i.e., a pill and condom user would be categorized as more effective method user). We conducted a sensitivity analysis about the categorization of ten women who indicated they used other methods.

Diabetes status was the primary predictor. Capillary whole blood was collected from a finger stick and analyzed to determine A1C; the high reliability and validity of this measure have been documented elsewhere (Nguyen et al., 2014; Whitsel et al., 2012). Women were categorized as having diabetes if they had an A1C greater than or equal to 6.5%, self-reported diabetes diagnosis (an affirmative answer when asked if she had a "history of being told by a doctor or health care professional that you have diabetes (if female, outside of pregnancy)"), or documentation of anti-hyperglycemic medication use in a prescription inventory of the previous four weeks. Women were categorized as having prediabetes if their A1C was between 5.7% and 6.4% without a history of a diabetes diagnosis or anti-hyperglycemic medication use. Women were categorized as normoglycemic if they had no evidence of prediabetes or diabetes. These criteria reflected ADA clinical practice guidelines and are described elsewhere (Whitsel et al., 2012). Type 1 diabetes mellitus and type 2 diabetes mellitus were not distinguishable in this survey.

Additionally, all women with diabetes were categorized by diagnosis status and glycemic control. First, women with diabetes were categorized as diagnosed if they had a self-reported diabetes diagnosis or took anti-hyperglycemic medications, and undiagnosed if they had neither. Second, women with diabetes were categorized as having suboptimal preconception glycemic control or not. Suboptimal preconception glycemic control was operationalized as A1C greater than or equal to 6.5% based on the ADA's recommended glycemic targets before pregnancy. Although the ADA considers 7% to be an appropriate goal for many adults who are not pregnant, we use the ADA's more conservative criterion for the preconception period (ADA, 2018). By this definition, all undiagnosed women in the sample have A1C greater than or equal to 6.5%. Some women with diagnosed diabetes had an A1C greater than or equal to 6.5%, whereas some had A1C less than 6.5%, likely because of treatment and lifestyle changes.

Analytic models controlled for characteristics which have been linked to diabetes risk and contraceptive behavior: demographic characteristics (race/ethnicity, insurance type, limited access to healthcare in the prior 12 months, and educational attainment) and BMI, with height and weight measured by field interviewers (Agency for Healthcare Research and Quality, 2001; Chuang et al., 2005; Cowie et al., 2009; Geiss et al., 2014; Willi et al., 2015), Educational attainment was a proxy for socioeconomic position relevant to health status because, in this age range, educational attainment is typically more stable than income (Kawachi et al., 2010). We also conducted a sensitivity analysis in which we included age in the model.

We used STATA version 14.1 (StataCorp LLC, College Station, TX) with SVY and SUBPOP commands to conduct design-based analyses that accounted for stratification, clustering, and unequal probability of selection (Heeringa, West, & Berglund, 2010). Application of the survey weights produced unbiased weighted population estimates of diabetes prevalence and contraceptive use. We used Taylor Series Linearization to perform design-based standard error computations. Associations were tested with the second order Rao-Scott design-adjusted F test, with the null hypotheses of independence. We modeled diabetes status as a predictor of contraceptive use with pseudo maximum-likelihood multinomial logit regression. We exponentiated beta coefficients to produce adjusted odds ratios (aORs) with 95% confidence intervals (95% CI). The overall significance of each predictor was examined with an adjusted Wald test. In order to model diagnosis status and suboptimal preconception glycemic control as predictors of contraceptive use, we conducted an additional unconditional domain analysis of women with diabetes. All models adjusted for demographic characteristics and BMI. All tests were two-tailed, with a 0.05 significance level. Institutional review board approval was obtained from the University of North Carolina at Chapel Hill.

Results

Most sexually active, non-pregnant women aged 24–32 years used birth control in the prior year (Table 3.2). The effectiveness of contraception used had significant bivariate associations with demographic variables, BMI, and diabetes status (all $P < .001$). We estimated that 20.8% of the population had prediabetes, and 5.9% had diabetes. More women with diabetes used less effective contraception (33.6% vs 25.2%) or no contraception (28.8% vs 16.4%) than their normoglycemic peers ($P < .001$).

In the multinomial analysis, compared to women with normoglycemia, women with diabetes had greater adjusted odds of using no contraception (aOR 1.90; 95% CI, 1.25−2.87) than more effective contraception (Table 3.3). There were not significant differences between use of less effective and more effective methods by women with diabetes compared to women with normoglycemia. Contraceptive use did not differ between women with prediabetes and normoglycemia.

Demographic characteristics and BMI were significant predictors (Table 3). Using no contraception was less likely among non-Hispanic black women but more likely among women with less education or who had obesity than their respective referents. Use of less effective contraceptive, rather than more effective contraception, was more likely among non-Hispanic black women, Hispanic women, women with less education, women without insurance, and women without access to healthcare than their respective referents.

We conducted a sensitivity analysis, categorizing the women who used "other methods" as more effective, less effective, or excluded from the analysis. We saw minor changes in coefficients and no changes in statistical significance. We report the analysis excluding those who reported other methods. We also examined the addition of age as a covariate; age did not change the values of the estimates or the statistical significance of other variables in any meaningful way.

We estimate that of women with diabetes ages 24−32, 60.6% were diagnosed (n = 213) and 56.0% had suboptimal preconception glycemic control indicated by A1C greater than or equal to 6.5% (n = 241). Among women with diabetes whose A1C was greater than or equal to 6.5%, 70.4% were undiagnosed and 29.6% were diagnosed.

Contraceptive use was significantly associated with diagnosis status ($P < .001$) (Table 3.4). Over half of undiagnosed women used less effective contraception (51.1%); using no contraception and more effective contraception were both more common among diagnosed than undiagnosed women with diabetes. In an adjusted multinomial model (Table 3.5), the association remained, indicating that undiagnosed women had greater odds of using less effective contraceptive, rather than more effective contraception, compared to diagnosed women (aOR 3.39, 95% CI, 1.44−7.96).

Table 3.4 also indicates a similar significant association between suboptimal preconception glycemic control and contraceptive use among women with diabetes ($P <$ .001). Nearly half of the women with A1C greater than or equal to 6.5% used less effective contraception (45.4%). In the adjusted model (Table 3.6), the association between glycemic control and contraceptive use remained significant because women with A1C greater than or equal to 6.5% had significantly lower odds of using no contraception than less effective contraception compared to women with A1C below 6.5% (aOR 0.31; 95% CI, 0.13−0.74; p =

.009; not shown). The step-down tests comparing no or less effective to more effective contraception were not significant.

As seen in Tables 3.5 and 3.6, Hispanic women with diabetes were more likely to use less effective contraception and less likely to use no contraception than non-Hispanic white women with diabetes. Women with obesity who had diabetes were more likely to use no contraception than women with underweight or normal weight with diabetes.

Discussion

To our knowledge, this is the first study to use a population-based sample to describe contraceptive use among women with biomarker-identified diabetes. While the majority of women with normoglycemia used more effective contraception, most women with diabetes were using either less effective contraception or no contraception. Our data supported the hypothesis that women with diabetes had higher odds of using no method, rather than a more effective method, in comparison to women with normoglycemia.

Our findings add to the available evidence about contraceptive use by women with diabetes, which has largely described only women who are diagnosed. Two previous studies found no differences in the odds of contraception non-use by women with diagnosed diabetes compared to normoglycemic women (Chuang et al., 2005; Vahratian et al., 2009). In contrast, we found that women with diabetes had significantly greater adjusted odds of not using contraception when we aggregated women with diagnosed diabetes and undiagnosed diabetes.

Certified nurse-midwives and other providers should be prepared to provide patient-centered care to sexually active women with diabetes who are not using contraception. Patients who could become pregnant deserve clear information about the possibility of complications and means to reduce risks from providers who respect their reproductive autonomy. Concerns about the inadequate provision of diabetes-specific preconception care have been voiced (Bond, 2015; Kachoria & Oza-Frank, 2014; Varughese et al., 2007), and are lent weight by our finding that nearly 20% of women with an A1C greater than or equal to 6.5% were using no contraception.

Since many women in this age cohort are unaware of their diabetes status or glycemic control (Britton, Hussey, Crandell, et al., 2018), our findings support structuring preconception care to be universal and routine in primary care, including midwifery practice (American College of Nurse-Midwives, 2012; Bond, 2015; Peterson et al., 2015). High rates of undiagnosed diabetes among young adult women highlight the importance of adhering to the ADA's diabetes screening criteria for providers serving this patient population (ADA, 2018). Furthermore because achieving and then sustaining glycemic control requires constant maintenance, preventing unintended pregnancies while A1C is greater than or equal to 6.5% also requires undisrupted access to primary care without financial or institutional barriers. Policies should support access to quality care that addresses both family planning and diabetes management needs.

According to the CDC's Medical Eligibility Criteria for Contraceptive Use, women with diabetes may typically use the contraceptive method of their choice (with the exception that women who have had diabetes for more than 20 years or have vascular damage may be contraindicated from using Depo-Provera or combined hormonal contraceptives) (CDC, 2016). In Add Health, most women with diabetes used less effective contraception, which may be preferable to women who desire methods which are generally less expensive, available without a prescription or healthcare interaction, non-hormonal, or prevent transmission of sexually transmitted infections (Jackson, Karasek, Dehlendorf, & Foster, 2016). Respecting women's preferences about contraception features is essential for preventing reproductive coercion. It is also critical for providers and researchers to identify and dismantle barriers encountered by women with diabetes who are using less effective contraception but desire more effective methods.

Our findings offer population estimates of women who need diabetes-specific reproductive healthcare, including both care that prevents and prepares for pregnancy in the context of diabetes management. In our discussion, we highlight the women who are using no contraception or less effective methods as they more likely to become pregnant than women who are using more effective methods (Hatcher et al., 2018). However, we do not quantify unmet contraceptive need because Add Health only queries women's pregnancy intentions retrospectively after pregnancies are reported. Prospective pregnancy attitudes at the time of data collection were not collected. In the general population, 4.5% of women ages 15−44 are not using contraception because they were seeking pregnancy, so it is reasonable to assume an unknown proportion of contraception non-users in this sample are as well (Daniels et al., 2015). In the future, the unmet contraceptive need could be discerned by data collection that includes concurrent determination of pregnancy intentions, current contraceptive use and A1C.

Having the full spectrum of reproductive health services available may be particularly important for women with diabetes since data suggests diabetes can complicate pregnancy intentions. Some women with diabetes report feeling ambivalence about childbearing because they both felt desire for pregnancy and fear of diabetes-associated risks (McCorry, Hughes, Spence, Holmes, & Harper, 2012). Women reported that guilt about diabetes harming their offspring delayed their plans for pregnancy (Spence, Alderdice, Harper, McCance, & Holmes, 2010) or made it hard for them to think about planning (Paiva, 2016). Women may perceive diabetes to reduce their fertility, which some women find distressing and can make preconception care, including contraception, seem irrelevant (Holing et al., 1998; Murphy et al., 2010; St. James et al., 1993). Additionally, women with diabetes have reported great happiness about unintended pregnancies (Holing et al., 1998). More research is needed to understand how women want family planning and preconception care incorporated into diabetes management. Future research should continue to build on the emerging evidence that the postpartum period may be a particularly promising time for innovations in family planning service delivery (Schwarz et al., 2017).

We noted two other trends in our data. In every model, women with obesity were more likely to use no contraception rather than more effective contraception, and Hispanic women were more likely to use less effective rather than more effective contraception. Women from the groups most affected should be invited to be collaborators, providing insight about how they understand the myriad factors that influence their contraceptive utilization and input about the acceptability of interventions to address any unmet contraceptive need.

We note several limitations. Our analysis being cross-sectional, we do not suggest that diabetes motivates contraceptive use; rather, we are describing the observable patterns of contraceptive use among women with diabetes. Unfortunately, our description cannot distinguish type 1 diabetes mellitus and type 2 diabetes mellitus, but our findings are still meaningful because elevated blood glucose endangers pregnancies of women with both kinds of pre-pregnancy diabetes (ADA, 2018). Generalizability of our findings is limited because some contraceptive methods listed in Add Health are no longer on the market in the United States, and new forms of the contraceptive implant (e.g., Implanon, Nexplanon) have become available since data were collected. Add Health did not contain data about how long participants used each method, whether multiple methods were used concurrently or consecutively, or satisfaction with the method; those dimensions should be explored in future research.

Since these data were collected in 2007–2009, guidelines around the long-acting reversible contraceptives (LARC, which includes IUDs and implants) have changed, and the Patient Protection and Affordable Care Act (ACA) significantly reduced out-of-pocket contraceptive expenses (A. Law et al., 2016). Unsurprisingly, LARC use has increased significantly between 2008-2014 (Kavanaugh & Jerman, 2018), so Add Health would not be an ideal dataset for answering questions about current LARC use and thus we did not focus our inquiry on those methods. An analysis of the 2008−2014 National Survey of Family Growth (NSFG) demonstrates most of the significant changes between 2008 and 2014 occurred within the more effective method category: use of sterilization decreased by 8.4 percentage point, use of LARC increased by 8.3 percentage points, and use of combined hormonal methods did not significantly change (Kavanaugh & Jerman, 2018). We felt comfortable using Add Health data from 2007–2009 because the significant changes in the less effective method category between 2008 and 2014 were smaller (2.9 percentage point increase in use of withdrawal and 1.0 percentage point increase in use of natural family planning) and no changes were seen in the percentage of women at risk of unintended pregnancy who used no method, despite the ACA ostensibly making all prescription contraceptives more accessible (Kavanaugh & Jerman, 2018).

Despite its limitations, we determined that Add Health is more suitable for addressing our hypotheses than other population datasets. In particular, the NSFG could not be used to address our hypotheses because diabetes status is not determined by biomarker. The National Health and Nutrition Examination Survey (NHANES), the population-based sample frequently used to generate population estimates about biomarker-identified diabetes, has few contraceptive questions and a smaller number of young adults than Add Health. Since diabetes is increasingly common among women of reproductive age, data should be collected to update these findings. Until then, this is the best estimate that is available of family planning behaviors of young adult women with diagnosed and undiagnosed diabetes in the United States.

Women with diabetes in young adulthood are using more effective contraception less than their normoglycemic peers. Evaluating and improving family planning for women with current or potential glucose dysregulation is critical for helping women achieve reproductive goals while minimizing the risks associated with elevated blood glucose during pregnancy.

Table 3.1. Categorization of contraceptive methods by effectiveness.

More Effective Contraception[a]	Less Effective Contraception[a]
tubal ligation/sterilization	condoms (rubbers)
vasectomy	female condom
IUD (intrauterine device), coil, loop	diaphragm, cap or shield
emergency IUD insertion	natural family planning (safe periods by temperature, cervical mucus test)
Norplant	rhythm or safe period by calendar;
birth control pills	emergency contraception or “morning after” pill
Patch (Ortho Evra)	withdrawal (pulling out)
ring (NuvaRing)	vaginal sponge
shot (Depo-Provera)	contraceptive film
	spermicide foam, jelly, creme, suppositories

[a] wording is as used on the survey

Table 3.2. Demographic characteristics of sexually active, non-pregnant women ages 24-32 in Add Health, Wave IV, 2007–2009 (N=5548).

	More effective contraception[a, b]	**Less effective contraception**[a, c]	**No contraception**[a]	**Total**	***P***[d]
Total, n (%)	3031 (55.3)	1580 (26.7)	937 (18.1)	5548	
Race/ethnicity, n (%)					< .001
Non-Hispanic white	1862 (58.5)	679 (22.8)	563 (18.7)	3104	
Non-Hispanic black	577 (45.1)	510 (39.5)	192 (15.4)	1279	
Hispanic	415 (51.1)	277 (30.2)	133 (18.7)	825	
Native American	17 (50.0)	[e]	[e]	37	
Asian	160 (54.0)	97 (27.8)	46 (18.2)	303	
Education, n (%)					< .001
College graduate or more	1274 (66.1)	492 (23.2)	191 (10.7)	1957	
Some college or vocational school	1311 (53.5)	731 (27.8)	472 (18.7)	2514	
High school graduate	313 (43.2)	237 (29.8)	184 (27.0)	734	
Less than high school	133 (39.6)	120 (29.7)	90 (30.7)	343	
Insurance, n (%)					< .001
Private insurance	2327 (59.3)	1,033 (24.3)	594 (16.4)	3954	
Medicaid	264 (48.2)	190 (31.3)	123 (20.5)	577	
No insurance	440 (44.8)	357 (32.6)	220 (22.6)	1017	
Access to Care, n (%)					< .001
Had access	2369 (57.8)	1139 (25.3)	649 (16.9)	4,157	
Lacked access	662 (47.8)	441 (30.8)	288 (21.3)	1,391	
Body Mass Index (BMI), n (%)					< .001
Normal/underweight	1288 (61.7)	570 (25.7)	263 (12.5)	2,121	
Overweight	797 (58.5)	389 (25.7)	207 (15.8)	1,393	
Obese	946 (46.1)	621 (28.4)	467 (25.5)	2,034	
Diabetes Status, n (%)					< .001
Normoglycemia	2242 (58.4)	1045 (25.2)	602 (16.4)	3,889	
Prediabetes	625 (49.2)	412 (30.0)	241 (20.8)	1,278	
Diabetes	164 (37.6)	123 (33.6)	94 (28.8)	381	

[a] *Unweighted n reported with weighted row percentages.*
[b] *More effective contraceptive methods are tubal ligation/sterilization; vasectomy; IUD (intrauterine device), coil, loop; emergency IUD insertion; Norplant; birth control pills; Patch (Ortho Evra); ring (NuvaRing); and shot (Depo-Provera).*
[c] *Less effective methods are condoms (rubbers); female condom; diaphragm, cap or shield; natural family planning (safe periods by temperature, cervical mucus test); rhythm or safe period by calendar; emergency contraception or "morning after" pill; withdrawal (pulling out); vaginal sponge; contraceptive film; and spermicide foam, jelly, creme, suppositories.*
[d] *Bivariate associated tested with Rao-Scott design-adjusted F test.*
[e] *Cell counts too small to report per Add Health guidelines.*

Table 3.3. Odds of less effective or no contraception use, instead of more effective contraception use, by sexually active, non-pregnant women ages 24-32 in Add Health, Wave IV, 2007–2009 (N=5548).

	Less effective contraception[a,b] aOR (95% CI)	**No contraception[a]** aOR (95% CI)	***P*[c]**
Diabetes status			.03
Normoglycemia	Ref	Ref	
Prediabetes	1.13 (0.91−1.40)	1.17 (0.87−1.57)	
Diabetes	1.45 (1.00−2.11)	1.90 (1.25−2.87)	
Race/ethnicity			< .001
Non-Hispanic white	Ref	Ref	
Non-Hispanic black	1.92 (1.51−2.45)	0.75 (0.58−0.96)	
Hispanic	1.39 (1.02−1.90)	0.91 (0.67−1.23)	
Native American	1.92 (0.67−5.48)	0.40 (0.08−2.15)	
Asian	1.39 (0.87−2.22)	1.32 (0.64−2.72)	
Education			< .001
College graduate or more	Ref	Ref	
Some college or vocational school	1.22 (0.98−1.52)	1.81 (1.41−2.32)	
High school graduate	1.53 (1.10−2.13)	3.01 (2.12−4.27)	
Less than high school	1.58 (1.05−2.38)	3.91 (2.57−5.95)	
Insurance			.02
Private insurance	Ref	Ref	
Medicaid	1.18 (0.85−1.64)	0.92 (0.66−1.26)	
No insurance	1.46 (1.16−1.84)	1.25 (0.96−1.65)	
Access to Care			.048
Had access	Ref	Ref	
Lacked access	1.25 (1.04−1.50)	1.22 (0.96−1.55)	
Body Mass Index (BMI)			< .001
Normal or underweight	Ref	Ref	
Overweight	0.97 (0.79−1.18)	1.23 (0.94−1.59)	
Obese	1.14 (0.92−1.42)	2.18 (1.66−2.85)	

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval

[a] The base outcome is more effective contraception use. More effective contraceptive methods are tubal ligation/sterilization; vasectomy; IUD (intrauterine device), coil, loop; emergency IUD insertion; Norplant; birth control pills; Patch (Ortho Evra); ring (NuvaRing); and shot (Depo-Provera). Outcome modeled with multinomial logit regression.

[b] Less effective methods are condoms (rubbers); female condom; diaphragm, cap or shield; natural family planning (safe periods by temperature, cervical mucus test); rhythm or safe period by calendar; emergency contraception or "morning after" pill; withdrawal (pulling out); vaginal sponge; contraceptive film; and spermicide foam, jelly, creme, suppositories.

[c] Adjusted Wald Test conducted.

Table 3.4. Contraception methods used by sexually active, non-pregnant women with diabetes ages 24-32 in Add Health, Wave IV, 2007–2009 (N=381).

	More effective contraception[a,b]	Less effective contraception[a,c]	No contraception[a]	*P*[d]
Diagnosis status[e], n (%)				< .001
Diagnosed	98 (43.3)	51 (22.2)	64 (34.5)	
Undiagnosed	66 (28.8)	72 (51.1)	30 (20.1)	
Glycemic control, n (%)				< .001
A1C < 6.5%	65 (41.3)	31 (18.6)	44 (40.2)	
A1C $\geq$ 6.5%	99 (34.7)	92 (45.4)	50 (19.9)	

[a] *Unweighted n reported with weighted row percentages.*
[b] *More effective contraceptive methods are tubal ligation/sterilization; vasectomy; IUD (intrauterine device), coil, loop; emergency IUD insertion; Norplant; birth control pills; Patch (Ortho Evra); ring (NuvaRing); and shot (Depo-Provera).*
[c] *Less effective methods are condoms (rubbers); female condom; diaphragm, cap or shield; natural family planning (safe periods by temperature, cervical mucus test); rhythm or safe period by calendar; emergency contraception or "morning after" pill; withdrawal (pulling out); vaginal sponge; contraceptive film; and spermicide foam, jelly, creme, suppositories.*
[d] *Rao-Scott design-adjusted F test conducted.*
[e] *Diagnosis status based on self-report or use of anti-hyperglycemic medications.*

Table 3.5. Adjusted odds of less effective or no contraceptive use, instead of more effective contraceptive use, by diagnosis status of women with diabetes ages 24-32 in Add Health, Wave IV, 2007–2009 (N=381).

	Less effective contraception[a,b] aOR (95% CI)	**No contraception**[a] aOR (95% CI)	***P***[c]
Diagnosis Status[d]			.02
Diagnosed	Ref	Ref	
Undiagnosed	3.39 (1.44−7.96)	1.46 (0.54−3.94)	
Race/ethnicity			< .001
Non-Hispanic white	Ref	Ref	
Non-Hispanic black	1.21 (0.45−3.25)	0.48 (0.18−1.23)	
Hispanic	2.70 (1.01−7.19)	0.20 (0.05−0.72)	
Native American	[e]	[e]	
Asian	[e]	[e]	
Education			.60
College graduate or more	Ref	Ref	
Some college or vocational school	0.65 (0.26−1.65)	1.45 (0.52−4.08)	
High school graduate	0.65 (0.18−2.28)	1.60 (0.53−4.80)	
Less than high school	1.58 (0.41−6.19)	1.18 (0.20−7.16)	
Insurance			.21
Private insurance	Ref	Ref	
Medicaid	1.99 (0.78−5.07)	1.01 (0.29−3.48)	
No insurance	2.43 (0.86− 6.84)	2.31 (0.95−5.65)	
Access to Care			.49
Had access	Ref	Ref	
Lacked access	1.22 (0.58−2.56)	0.70 (0.31−1.58)	
BMI			.27
Normal or underweight	Ref	Ref	
Overweight	1.83 (0.57−5.87)	2.68 (0.60−11.80)	
Obese	1.57 (0.49−5.04)	3.92 (1.07−14.41)	

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval.

[a] *The base outcome is more effective contraception use. More effective contraceptive methods are tubal ligation/sterilization; vasectomy; IUD (intrauterine device), coil, loop; emergency IUD insertion; Norplant; birth control pills; Patch (Ortho Evra); ring (NuvaRing); and shot (Depo-Provera). Outcome modeled with multinomial logit regression.*

[b] *Less effective methods are condoms (rubbers); female condom; diaphragm, cap or shield; natural family planning (safe periods by temperature, cervical mucus test); rhythm or safe period by calendar; emergency contraception or "morning after" pill; withdrawal (pulling out); vaginal sponge; contraceptive film; and spermicide foam, jelly, creme, suppositories.*

[c] *Adjusted Wald Test conducted.*

[d] *Diagnosis status based on self-report or use of anti-hyperglycemic medications.*

[e] *Cell counts too small to report per Add Health guidelines.*

Table 3.6. Adjusted odds of less effective or no contraceptive use, instead of more effective contraceptive use, by glycemic control of women with diabetes ages 24-32 in Add Health, Wave IV (N=381).

	Less effective contraception[a,b] aOR (95% CI)	**No contraception**[a] aOR (95% CI)	***P***[c]
Glycemic Control			.03
A1C < 6.5%	Ref	Ref	
A1C ≥ 6.5%	2.04 (0.79−5.29)	0.62 (0.25−1.54)	
Race/ethnicity			< .001
Non-Hispanic white	Ref	Ref	
Non-Hispanic black	1.76 (0.68−4.53)	0.83 (0.35−1.93)	
Hispanic	2.85 (1.09− 7.49)	0.22 (0.06−0.81)	
Native American	[d]	[d]	
Asian	[d]	[d]	
Education			0.58
College graduate or more	Ref	Ref	
Some college or vocational school	0.64 (0.26−1.62)	1.57 (0.55−4.50)	
High school graduate	0.63 (0.19−2.11)	1.75 (0.57−5.42)	
Less than high school	1.24 (0.26−5.79)	1.09 (0.17−7.02)	
Insurance			0.13
Private insurance	Ref	Ref	
Medicaid	2.22 (0.84− 5.88)	1.08 (0.28− 4.17)	
No insurance	2.39 (0.87−6.54)	2.41 (0.98−5.95)	
Access to Care			0.56
Had access	Ref	Ref	
Lacked access	1.23 (0.57−2.62)	0.8 (0.3−1.7)	
BMI			0.27
Normal/underweight	Ref	Ref	
Overweight	1.79 (0.58−5.53)	2.69 (0.63−11.58)	
Obese	1.48 (0.49−4.51)	3.80 (1.05−13.77)	

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval.

[a] *The base outcome is more effective contraception use. More effective contraceptive methods are tubal ligation/sterilization; vasectomy; IUD (intrauterine device), coil, loop; emergency IUD insertion; Norplant; birth control pills; Patch (Ortho Evra); ring (NuvaRing); and shot (Depo-Provera). Outcome modeled with multinomial logit regression.*

[b] *Less effective methods are condoms (rubbers); female condom; diaphragm, cap or shield; natural family planning (safe periods by temperature, cervical mucus test); rhythm or safe period by calendar; emergency contraception or "morning after" pill; withdrawal (pulling out); vaginal sponge; contraceptive film; and spermicide foam, jelly, creme, suppositories.*

[c] *Adjusted Wald Test conducted.*

[d] *Cell counts too small to report per Add Health guidelines.*

CHAPTER 4: POSTPARTUM CONTRACEPTIVE USE, ATTITUDES, AND BELIEFS OF WOMEN WITH PREPREGNANCY TYPE 1 OR TYPE 2 DIABETES MELLITUS

Introduction

An increasing number of pregnant women have prepregnancy diabetes (Admon et al., 2017; Bardenheier et al., 2015; Correa et al., 2014). The American Diabetes Association (ADA) recommendations for preconception care include use of contraception until women are ready for a pregnancy, ideally with glycated hemoglobin (A1C) below 6.5% (ADA, 2018). When blood glucose is elevated, women with type 1 diabetes mellitus (T1DM) or type 2 diabetes mellitus (T2DM) experience higher rates of perinatal loss, congenital malformations, preterm birth, preeclampsia, macrosomia, Cesarean section, and fetal programming for obesity and T2DM later in life (Berry et al., 2016; Cyganek et al., 2011; Ehrenberg et al., 2004; Macintosh, 2006; Portha et al., 2011; Timar et al., 2014). Although an estimated $767 million in direct medical costs and $3.6 billion in lost productivity could be saved with universal preconception care to all women with prepregnancy diabetes (Peterson et al., 2015; Wahabi et al., 2010), a little over half of women with prepregnancy diabetes obtain preconception care (Kachoria & Oza-Frank, 2014).

Postpartum contraception protects a window of time before a subsequent pregnancy in which women with diabetes can recover from the delivery and address postpartum mental and physical health needs (Kjos, 2007). Postpartum contraception is a critical patient-centered service for women who desire no more children. If women desire more children, then postpartum contraception use is a tool for avoiding short interpregnancy intervals and delaying subsequent conception while striving to establish euglycemia (Kjos, 2007; Thiel de Bocanegra, Chang, Howell, & Darney, 2014). In essence, the postpartum period can function as the preconception period for subsequent potential pregnancies.

The evidence about postpartum contraceptive use among women with prepregnancy diabetes is scant and mixed. On the one hand, Perritt and colleagues found significantly lower rates of postpartum contraceptive use among women with prepregnancy diabetes than women without any chronic medical problems, despite similar rates of antenatal contraceptive counseling (Perritt, Burke, Jamshidli, Wang, & Fox, 2013). On the other hand, Schwarz et al. found that among the women aged 15−44 who had a live birth and submitted claims to Medi-Cal, women with prepregnancy diabetes were more likely to use sterilization or barrier methods and less likely to use reversible methods or no contraception than their peers without diabetes (Schwarz et al., 2017). A better understanding of the postpartum attitudes, beliefs, and behaviors of women with diabetes is crucial for preparing the healthcare workforce to meet their family planning needs.

Attitudes may be linked to family planning behaviors among women with diabetes (Charron-Prochownik et al., 2015; Grady & Geller, 2016; Komiti et al., 2018; Wang, Charron-Prochownik, Sereika, Siminerio, & Kim, 2006). When women perceive barriers to contraception use and diabetes-specific preconception care, they express lower intention to utilize either (Wang et al., 2006). High self-efficacy about contraception use and diabetes-specific preconception care have been associated with perceived usefulness of preconception counseling and birth control (Grady & Geller, 2016), preconception care seeking behaviors (Komiti et al., 2013), and intention to use contraception and preconception care (Wang et al., 2006). Low perception of the benefits of contraception use and preconception care are recurrent themes in the qualitative literature about women with diabetes not using contraception and preconception care (Charron-Prochownik, Sereika, Falsetti, et al., 2006; Charron-Prochownik et al., 2015; Chuang et al., 2010; Earle et al., 2017; Holing et al., 1998; Mccorry et al., 2012; Murphy et al., 2010; O'Higgins, Mcguire, Mustafa, & Dunne, 2014; Shawe, Smith, & Stephenson, 2011; St. James et al., 1993). Through the lens of Pender's Revised Health Promotion model (Pender, 2011), we conceptualized perception of benefits, perception of barriers, and self-efficacy as potential attitudinal antecedents of a key preconception behavior, contraceptive use, in order to identify potentially modifiable targets for nursing interventions.

We piloted a survey with women who had prepregnancy diabetes and were receiving postpartum care at a high-risk obstetrics clinic. Our primary objective was to describe the postpartum attitudes, beliefs, and behaviors of women with prepregnancy diabetes. Our secondary objective was to test the association between postpartum contraceptive use and three contraceptive attitudes: self-efficacy, perception of barriers, and perception of benefits related to contraceptive use and preconception care.

Methods

Design and Participants

Our sample included women, aged 18 or older, with T1DM or T2DM. The ADA recommendations for contraception use and preconception care intended to mitigate the harms of elevated blood glucose early in pregnancy are not relevant to women with gestational diabetes mellitus (GDM), which manifests mid-pregnancy (ADA, 2018). Women under age 18 were excluded because adolescents may have different family planning needs than adult women (Oringanje et al., 2009). Women who could not speak and read English were excluded. Women were not approached if they experienced a fetal demise, a major malformation, or if study personnel were instructed not to contact the woman, either by clinic staff assessing her as too distressed or notation in the medical records indicated that she should not be contacted.

Recruitment was performed at three high-risk obstetric clinics at an academic medical center in the Southeast which receives regional referrals from throughout the state. Sites were within 30 miles of each other, and some participants obtained care at more than one site. Eligible women were identified through the electronic health records, and contacted about study participation either in person at the clinic or remotely, by phone or email, between 37 weeks gestation and 8 weeks postpartum. When women were approached in person at a clinic site, study personnel described the study procedures, goals, benefits, and risks out loud, allowed the woman read the informed consent document, answered her questions, and then obtained informed consent with her signature. When women were recruited remotely over the phone or email, they were consented using an IRB-approved version of the informed consent document, which was housed online in the Qualtrics platform and could be signed electronically, with study personnel available for questions by phone or email.

Procedures

Data were collected from women between four and eight weeks postpartum. Women who were consented between 37 weeks gestation and four weeks postpartum were sent the link when they became four weeks postpartum. Women who consented remotely between four and eight weeks postpartum were immediately invited to complete the online survey, which was securely housed on the Qualtrics platform. Women who were consented in person between four and eight weeks postpartum were given the option of receiving a link they could open on their own device or of completing the survey at that time on a study iPad. Women who completed the survey were given $20. All study procedures were approved by the University of North Carolina at Chapel Hill.

Measures

On the survey, women were asked what contraceptive method, if any, they were using. The procedure/prescription methods included female sterilization (tubal ligation, tubes tied or blocked; male sterilization (vasectomy); intrauterine device (IUD) without hormones (Paragard); intrauterine device (IUD) with hormones (Mirena, Skyla, Liletta); etonogestrel implant (Norplant, Implanon, or Nexplanon); birth control pills, patch, or ring; the depo-provera injection (DMPA); diaphragms; or emergency contraception. The non-prescription methods included male or female condoms; withdrawal; vaginal sponge; contraceptive film, suppository, or crème; and lactational amenorrhea (LAM). Women could indicate if they were using more than one method. For the analyses, women were assigned to a single category representing the most effective method used. Non-prescription methods are less effective than the procedure/prescription methods, except for perfectly executed LAM (Hatcher et al., 2018); however, it was beyond the scope of this study to assess LAM adherence. Women who used procedure/prescription and non-prescription methods were categorized as procedure/prescription method users. Non-users were asked why they were not using contraception and could provide multiple reasons. Women also answered questions about their postpartum sexual activity.

The independent variables of interest were three attitudes -- benefits, barriers, and self-efficacy towards contraception use -- derived from Pender's Revised Health Promotion

Model, which were measured with scales from the Reproductive Health Attitudes and Behaviors (RHAB) questionnaire (Charron-Prochownik, Wang, Sereika, Kim, & Janz, 2006; Pender, 2011). RHAB was developed and validated with adolescent women who had T1DM (Charron-Prochownik, Wang, Sereika, Kim, & Janz, 2006).The Cronbach's α was 0.65, 0.72, and 0.65 respectively for the RHAB Benefits scale, RHAB Barriers scale, and RHAB Self-Efficacy scale (Charron-Prochownik, Wang, Sereika, Kim, & Janz, 2006). Numerous items on the scales reference "preconception care" which was defined for participants as encompassing "achieving normal blood sugars, obtaining preconception counseling, and using effective birth control" (Charron-Prochownik, Wang, Sereika, Kim, & Janz, 2006).

The RHAB Benefits scale contains four items with scores ranging from 4-20; the RHAB Barriers scale contains five items with scores ranging from 0-25; and the RHAB Self-Efficacy scale contains six items with scores ranging from 0-60 (Charron-Prochownik, Wang, Sereika, Kim, & Janz, 2006). A higher score indicated a greater endorsement of the scale's theme. Since the three scales used had different ranges, we enhanced the comparability of our models by reporting the change of log odds in the dichotomous outcome for a one-half standard deviation increase.

Women were asked a series of single-item investigator-developed attitudinal questions about postpartum beliefs. Questions were based on themes which emerged in the qualitative literature with women who have diabetes (Charron-Prochownik, Sereika, Falsetti, et al., 2006; Charron-Prochownik et al., 2015; Chuang et al., 2010; Earle et al., 2017; Holing et al., 1998; Mccorry et al., 2012; Murphy et al., 2010; O'Higgins, Mcguire, Mustafa, & Dunne, 2014; Shawe, Smith, & Stephenson, 2011; St. James et al., 1993). The questions included whether diabetes influenced their choice of contraception; diabetes caused complications in their recent pregnancy; whether they believed contraception was less safe for women with diabetes; whether they believed contraception was less effective for women with diabetes; whether women with diabetes need contraception as much as women without diabetes; and whether diabetes makes it harder for women with diabetes to get pregnant. Women could agree, disagree, or indicate they did not know. In the analysis, due to sample size constraints, women who agreed were compared to women who either disagreed or did not know.

Women were asked their desire for future children and when they intended to next try to conceive, using wording modeled on the National Survey of Family Growth (NSFG) (CCD, 2016). Women who desired future children could indicate that their desired timing was within eighteen months, eighteen months to two years, two to five years, or more than five years.

The six-item London Measure of Unplanned Pregnancy (LMUP) scale was used to measure the degree to which the recent pregnancy was planned (Barrett, Smith & Wellings, 2004). Originally, the LMUP was validated in Britain, where the Cronbach's alpha was 0.92 and the test-retest reliability was 0.97 (Barrett, Smith & Wellings, 2004). After minor modifications, the LMUP was validated in the United States (U.S.), with a Cronbach's alpha of 0.78 with all item-total correlations over 0.20 and a weighted Kappa of 0.72 (Morof et al., 2012). LMUP scores range from 0−12, with higher values indicating that the pregnancy was planned, and was used as a continuous variable since the authors indicated cut-offs for a categorical variable had not been adequately validated (personal communication, 2018).

Demographic data included age, race and ethnicity, educational attainment, religion, parity, and health insurance. For women with Medicaid, we also asked how much longer they expected to have coverage as pregnancy Medicaid typically ends at 60 days postpartum in the state where data was collected (North Carolina Department of Health and Human Services, 2018). Diabetes characteristics included age of diabetes diagnosis, duration since diagnosis, and whether she had T1DM or T2DM.

Data Analysis

All analyses were performed in SAS, version 9.4 (SAS, Cary, NC, USA). Univariate and bivariate descriptive statistics were provided for women's demographic characteristics, diabetes characteristics, and postpartum attitudes, beliefs, and behaviors. For continuous variables, histograms were generated to evaluate normality. When continuous variables were not normal, we report medians and interquartile ranges (reported as p25−p75) instead of means and standard deviations.

We reported three levels of contraceptive use (procedure/prescription, non-prescription, or none) for demographic and diabetes characteristics. Due to sample size limitations, we compared the use of procedure/prescription contraception to non-prescription/no contraception when we performed hypothesis testing. We also collapsed categories for race and ethnicity, education, and insurance into two-level categories. For categorical variables, we performed analyses of associations with Fisher's exact test if 25% or fewer of the cells contained less than five observations and χ^2 test otherwise. When the normality assumption was not fulfilled for continuous variables, we used the non-parametric Wilcoxon test to test associations. We reported the Cronbach's alpha for the RHAB scales and LMUP, although we are underpowered. A sample size of 90 would have been adequate for the computation of Cronbach's alphas (Rouquette & Falissard, 2011).

We built three models of procedure/prescription postpartum contraception use with multiple logistic regression using scores for RHAB Benefits, RHAB Barriers, and RHAB Self-Efficacy respectively as the predictors. A priori, we determined that the models would adjust for demographic factors (age, race and ethnicity, educational attainment, insurance and type of diabetes) as well as whether sexual activity had resumed and LMUP score of how much the index pregnancy was planned. We planned to add any additional variables that were associated with procedure/prescription contraception use at the 0.05 significance level.

Our goal was to recruit 90 women, assuming, as reported by Schwarz et al., that approximately 30% use “strong” (equivalent to our category of procedure/prescription contraception) and 70% use “weak/no” (equivalent to the non-prescription methods/nothing) contraception. A total sample of 90 postpartum mothers allows for 80% power to detect a medium-large standardized mean difference of d = 0.65 between the two groups, in a two-tailed t-test with a significance level of 0.05 (Schwarz et al., 2006).

Results

Sample Characteristics

Between June 2017−September 2018, we identified 88 women in the electronic health record who fit the eligibility criteria (Figure 4.1). We approached or contacted 68 women, of whom 44 agreed to participate. The survey was completed by 40. Most participants completed the survey online (n = 39, 95.7%). Participants completed the survey between four and eight weeks postpartum with a median of 6 weeks.

Demographic Characteristics

Participants ranged from 21 to 44 years old, with the median age of 34 years old (Table 4.1). The majority of participants had a previous live birth (n = 27, 67.5%), non-

Catholic Christians (n = 30, 75.0%); and had completed some college or vocational training (n = 30, 75.0%). The plurality were non-Hispanic White (n = 13, 32.5%). Most participants had had some form of insurance (n = 32, 80%). Of the participants with Medicaid, 44.4% believed they would retain coverage for over a year (n = 4).

The sample contained 25.0% women with T1DM (n = 10) and 75.0% with T2DM (n = 30). Diabetes was diagnosed between age 5 and 44. The median age of diagnosis was 24 years old, and the median duration since diagnosis was 8.4 years. We were concerned that women with T1DM and T2DM might have significantly different demographic characteristics, so we tested the association between diabetes type and each demographic variable. No significant differences were seen in demographic characteristics between women with T1DM and T2DM (not shown). Diabetes characteristics were significantly different. Women with T1DM had been diagnosed between the ages of 5 and 21 years, whereas women with T2DM were diagnosed significantly older between the ages 13 and 44 years ($p < 0.001$, not shown). Women with T1DM had diabetes longer than women with T2DM (median 18.4 years versus 5.1 years, $p < 0.001$, not shown).

Behaviors, Beliefs, and Attitudes

Fifty percent of the sample had resumed sexual intercourse before completing the survey (n = 20) (Table 4.2). Resumption occurred between one and six weeks, with a median of 5 weeks. All but one reported that sex occurred once a week or less (n = 19).

Most participants were uncertain (n = 16, 40.0%) or did not want to have another child in their lifetime (n = 15, 37.5%). Of the nine women who did want another child, most desired to get pregnant within 2-5 years (n = 6, 66.7%). Only one woman wanted to become pregnant in less than 18 months and was currently sexually active without contraception use.

The majority of participants reported that they did not think about diabetes when making decisions about birth control (n = 25, 62.5%) and that they believed diabetes caused complications in their most recent pregnancy (n = 22, 55.0%). Women who believed they experienced complications were no more likely to think about diabetes when making contraceptive decisions than women who experienced no complications (p = 0.75, not shown). Few thought birth control was less safe (n = 5, 12.5%) or less effective (n = 2, 5.1%) for women with diabetes, or that women with diabetes need birth control less than women without (n = 2, 5.1%). However, 35.0% thought diabetes makes it harder for women to get pregnant (n = 14).

When we measured women's attitudes towards contraception, values were not normal and the median score on the RHAB Benefits scale was 16.0 out of 20.0, RHAB Self-Efficacy scale was 49.0 out of 60.0, and RHAB Barriers scale was 5.0 out of 25.0. In our sample, the standardized Cronbach's α for RHAB Benefits was 0.56 (n = 39), Barriers Scale was 0.71 (n = 38), and RHAB Self-Efficacy scale was 0.82 (n = 40).

Participants tended to characterize their recent pregnancies as planned with LMUP scores clustering at higher values (Figure 4.2). When asked, "Before you became pregnant, did you do anything to improve your health in preparation for pregnancy?" the most common action was taking folic acid or prenatal vitamins (n = 12, 30.0%). Eighteen women indicated that they did nothing (45.0%). In an open field, seven participants described improving diabetes control unprompted (17.5%). The standardized Cronbach's α for LMUP was 0.84 (n = 39).

Contraceptive Use

Almost a quarter of our participants used no postpartum contraception method (n = 9, 22.5%) (Figure 4.3). Of the contraceptive non-users, 89% did not want another pregnancy in the next 18 months (n = 8). Only three of the nine non-users gave at least one reason: her husband or partner did not want to use anything (n = 1), worried about side effects (n = 2), or were planning to start a contraceptive method (n = 2).

In our sample, 12.5% of women obtained a sterilization procedure (n = 5), 47.5% used a prescription method (n= 24), and 17.5% used a non-prescription method (n = 7) (Figure 4.3). Two male condom users indicated that they intermittently had unprotected intercourse. Among women using any contraception (n = 31), the most common methods were pills (n = 8, 25.8%), and IUDs with hormones (n = 7, 22.6%). Two male condom users and two women who used nothing indicated they planned to change their method (10.0%); one woman had not yet decided which method, but the other three indicated they desired procedure/prescription methods.

Bivariate Findings

No demographic characteristics or diabetes characteristics had a significant bivariate association with procedure/prescription contraception use (Table 4.1). We also noted that there was no difference in contraception use based on how soon after delivery women took the survey.

Women using procedure/prescription contraception had significantly higher mean RHAB Benefits scores ($p = 0.03$). Scores for RHAB Barriers and Self-Efficacy were not significantly different between women who did and did not use procedure/prescription contraception use (Table 4.2). Women who used procedure/prescription methods did not have higher mean LMUP scores than women who used non-prescription/no contraception. There were no significant bivariate associations between procedure/prescription contraception use and safety beliefs, effectiveness beliefs, complications beliefs, or considering diabetes when making contraceptive decisions.

Multiple Logistic Regression

In the unadjusted logistic model, for every additional half of a standard deviation increase in RHAB Benefit score, the odds of using procedure/prescription contraception increased by 1.53 (95% CI 1.02−2.27), and then by 1.73 (95% CI 1.05−2.84) when demographic characteristics were added to the model.

In their respective logistic models, one half standard deviation increase in RHAB Barriers and RHAB Self-Efficacy did not cause a significant increase in the odds of using procedure/prescription contraception, with or without adjustments.

Discussion

In our sample of postpartum women with prepregnancy diabetes, sixty percent were using contraception in the four to eight weeks after delivery. Women in our sample utilized highly effective procedure/prescription contraceptive methods more than in the previous study with which we generated our power calculation (Schwarz et al., 2006). The more that women perceived contraception use and preconception care to be beneficial, the more likely they were to use procedure/prescription contraception postpartum, even after controlling for demographic characteristics and other covariates.

Demographics

We identified a few notable characteristics of our sample. With the median age of 34 years old, we saw preconception diabetes affecting many women who were advanced maternal age during this pregnancy and would be in future pregnancies. However, as demographic trends indicate that T2DM is affecting more women earlier in life, the workforce should anticipate caring for more pregnancies affected by diabetes in younger cohorts as well (Britton, Hussey, Crandell, et al., 2018; Geiss et al., 2014)

Behaviors, Beliefs, and Attitudes

Since women who are not breastfeeding can ovulate as early as four weeks postpartum (Jackson & Glasier, 2011), postpartum contraception should be arranged promptly for women who resume sexual activity soon after delivery if they have no desire to become pregnant again. The majority of our sample desired to prevent or delay childbearing, which required timely postpartum contraceptive service delivery since sex was resumed as early as one week after delivery. Half of this postpartum sample had resumed sexual activity by the 4-8 week postpartum window, which is similar to other hospital-based samples of postpartum women in which 43%-51% of women had resumed sexual activity by six weeks (Chen et al., 2010; Rogers, Borders, Leeman, & Albers, 2009; Sok, Sanders, Saltzman, & Turok, 2016). Only one participant was actively pursuing the goal of becoming pregnant again at that time. Women who are not yet sexually active may also benefit from establishing a satisfactory contraceptive method before resumption, so unintended pregnancy prevention is in place when the possibility becomes real.

Our sample largely did not endorse the same concerns as have been captured in the qualitative literature with women with diabetes as motivating their contraception non-use, including diabetes making it harder to get pregnant or women with diabetes not needing contraception (Earle et al., 2017; Holing et al., 1998; Murphy et al., 2010; St. James et al., 1993) or contraception being unsafe or ineffective for women with diabetes (Charron-

Prochownik, Sereika, Wang, et al., 2006; Murphy et al., 2010; Shawe et al., 2011). Our findings suggest that contemporary American adults with diabetes may have different beliefs than those interviewed two decades ago (Holing et al., 1998; St. James et al., 1993), in adolescence (Charron-Prochownik, Sereika, Falsetti, et al., 2006), or in the United Kingdom (Earle et al., 2017; Murphy et al., 2010; Shawe et al., 2011). These differences underscore the importance of conducting current research with adult American women with diabetes despite the availability of a rich literature about women with diabetes in other contexts.

In our sample, most women had planned their index pregnancy. We were concerned about pregnancy planning because previous studies estimated the unintended pregnancy rate at 41%-78% (Holing et al., 1998; St. James et al., 1993). More recent data showed that women with chronic illnesses were more likely to have had an unplanned pregnancy than their healthier peers (Chor, Rankin, Harwood, & Handler, 2011), and numerous unintended pregnancy experiences were described in the qualitative literature (S. A. Collier et al., 2011; Earle et al., 2017; Mersereau et al., 2011; Murphy et al., 2010; Spence et al., 2010; Younger, 1993). Our findings were more similar to those of Perritt and colleagues, who found that women with diabetes were no more likely to have a mistimed or undesired pregnancy than women without medical conditions (Perritt et al., 2013). The LMUP score was not associated with contraceptive use, which differs from the literature suggesting that women with mistimed or unwanted pregnancies may be more likely to adopt highly effective postpartum contraception (Guzzo & Hayford, 2017). We attempted to probe women's reasons for contraception non-use, but two-thirds of the contraceptive non-users provided none. For women who can identify a reason, nursing care can be tailored to each of the reasons endorsed – fear of side effects, partner does not support her contraceptive use, and planning to start – to assure that women receive the counseling and care needed to support their contraceptive decision-making.

Unplanned pregnancies preclude the opportunity to engage in preconception care (Murphy et al., 2010). However, not all women who planned pregnancy their pregnancies optimized their preconception health in accordance with the ADA recommendations. Only 17.5% of women in our sample described attempting to improve glycemic control before conception, despite this being the cornerstone strategy for reducing the risks of fetal malformations during the embryonic period and other adverse pregnancy outcomes later in pregnancy (ADA, 2018). Women with diabetes have described not fully understanding the impact of diabetes on pregnancy or that preconception care could ameliorate risks (Charron-Prochownik, Wang, Sereika, Kim, & Janz, 2006a; Chuang et al., 2010; Murphy et al., 2010; O'Higgins et al., 2014). Furthermore, some women misunderstood that achieving elevated blood glucose before conception promotes healthy organ development in ways that cannot be ameliorated by prenatal care later in the pregnancy (Mccorry et al., 2012).

If women believed that a subsequent adverse pregnancy outcome could be prevented by using contraception until blood glucose was well-controlled, we might expect to see women who experienced a complication motivated to initiate an effective contraceptive method postpartum. However, the women who believed that diabetes caused complications in their last pregnancy were no more likely to use the procedure/prescription contraceptive methods than participants whose pregnancies were uncomplicated. The links between pregnancy outcomes, blood glucose management, pregnancy timing, and contraceptive use underlie preconception care, but do not seem to be widely understood, despite the advocacy by leaders in the field (Boggess & Berggren, 2015; Downs et al., 2010), and perhaps speak to the uncertainty about the optimal preconception protocol in this population (Tieu et al., 2017). To support the development of service delivery innovations that will be well-received and effective, we sought to better understand women's attitudes towards preconception care and contraception use.

Women in our sample had high scores on the RHAB Benefits and RHAB Self-Efficacy scales, and low scores on the RHAB Barriers scale. Conceptualized as potential antecedents to postpartum contraceptive use based on Pender's Revised Health Promotion Model (Pender, 2011), each attitude was modeled. Only RHAB Benefits scores were significantly associated with the use of procedure/prescription contraception.

The association between high perceptions of contraception's benefits and use of procedure/prescription methods is consistent with the converse observation that women may not seek out preconception care if they do not believe it has any value (Charron-Prochownik, Wang, et al., 2006; Chuang et al., 2010; Murphy et al., 2010; O'Higgins et al., 2014). In the data from qualitative literature, women with diabetes are more receptive to the positive information of preconception care than scare tactics (S. A. Collier et al., 2011; Mccorry et al., 2012). Providers must rise to the challenge of conveying worrisome or unwelcomed information with an empowering tone because women became frustrated with being told point blank not to have children (Spence et al., 2010), to wait to get pregnant until their blood glucose was lower (Lavender et al., 2010), or receiving disheartening preconception counseling (Griffiths, Lowe, Boardman, Ayre, & Gadsby, 2008). The stakes are high: women have delayed prenatal care when they have feared that providers will disapprove of their pregnancies (S. A. Collier et al., 2011; Edwards, Speight, Bridgman, & Skinner, 2016; Murphy et al., 2010; Spence et al., 2010). Similar to data that encouragement facilitates greater uptake of preconception care (O'Higgins et al., 2014), our findings suggest that a woman's perception of the benefits of preconception care and contraception may be a promising target for intervention. There is the caveat that women with diabetes have described feeling unmotivated to seek diabetes-specific care because they wanted to feel normal during pregnancy (Murphy et al., 2010). Future research should ascertain whether increasing perception of benefits increases contraceptive uptake, and whether benefits are counterbalanced by perception of barriers, a relationship suggested by the theoretical model but unable to be tested in our small sample (Pender, 2011).

Our findings about RHAB scores can be contextualized in evidence from other studies. In a study of adolescent women with T1DM, those with a high perception of barriers expressed lower intention to use contraception and preconception care (Wang et al., 2006), unlike our sample, where the RHAB Barriers score was not significant. Barriers have been described in the qualitative literature central to American women's struggle to access supplies and care to manage their blood sugar in preparation for pregnancy (Mersereau et al., 2011). Providers may alienate patients whose barriers to care go unacknowledged, as exemplified by the Hispanic women described delaying prenatal care because they anticipated providers would criticize them for poor glycemic control when they could not afford to comply with their treatment plan (S. A. Collier et al., 2011). Even in the United Kingdom, where the care is ostensibly available through the National Health System, women cited logistical and financial barriers to preconception care uptake (Murphy et al., 2010), such as taking time off work and the cost of hospital parking (Earle et al., 2017). We hypothesized that barriers to contraception might be particularly challenging to overcome for women as they also face the biological, psychological, and social demands of the postpartum period (Verbiest, Tully, & Stuebe, 2017). However, our findings did not provide supportive evidence that that postpartum women with diabetes encountered barriers to preconception care or contraception use as measured by the RHAB Barriers scale.

High self-efficacy scores have been associated with perceived usefulness of preconception counseling and birth control (Grady & Geller, 2016), preconception care seeking behaviors (Komiti et al., 2013), and intention to always use birth control when having sex, and to seek medical care and advice when planning a pregnancy (Wang et al., 2006), but were not significant in our model of postpartum contraceptive use. Wang also noted that higher self-efficacy scores were significantly associated with lower barriers scores (correlation coefficient, -0.29, $p < 0.01$) among adolescents with T1DM (Wang et al., 2006). With our underpowered analysis, we did not support a link between self-efficacy and contraceptive use postpartum but, as the Pender's model suggests, it may have an undetected role in how women manage their perception of barriers and subsequently enact health behaviors (Pender, 2011).

The RHAB scales and LMUP scale had not previously been used with adult postpartum women with T1DM and T2DM and performed moderately well. The values for the Cronbach's α was lower for RHAB Benefits in our sample than in the sample of adolescents used for validation, very close for RHAB Barriers, and higher for RHAB Self-Efficacy and LMUP. However, our sample size was underpowered for determination of Cronbach's α of scales.

Since we were underpowered, we caution against over-interpretation of non-significant findings. However, our sample size limitations do not undermine our findings of a significant relationship between perception of benefits and postpartum contraceptive use. We also urge caution against generalizing these findings to women who had severe complications, including fetal demise and significant malformations, who were not included in this sample. Additionally, because our data were collected at a single time point, we cannot assert that modifying contraceptive attitudes would change contraceptive use, though our findings suggest that the benefits attitude is a promising target for intervention.

To determine if certain attitudes predicted postpartum contraceptive use, we controlled for numerous demographic variables. However, we acknowledge that we did not control for every issue which may have affected women's choices. It was beyond the scope of this study to assess how breastfeeding goals affected women's contraceptive plans, postpartum mental health, or women's preference for contraceptive features. As the science moves forward, expanding the scope of inquiry to include those dimensions may be fruitful.

Postpartum women with preconception diabetes proved to be a hard-to-reach population, and through the study, we learned lessons about recruitment. Although we had engaged with partners in the clinical setting to determine if our recruitment plan was feasible, the institution served fewer women with diabetes than had been projected. Initially, our recruitment plan missed women who did not attend postpartum appointments at the high risk obstetrics clinic where they obtained prenatal care. We modified our recruitment plan to permit contact by phone or email. One benefit to modifying the recruitment strategy is that we diminished the bias in our findings against women who did not use procedure/prescription contraception which require interaction with a provider.

Our findings highlight the particular need for women with diabetes for high-quality postpartum contraceptive service delivery. Providing effective postpartum care that optimizes health may be a critical strategy for reducing future risks of adverse obstetrical outcomes and supporting women with diabetes to achieve their personal pregnancy goals.

Figure 4.1. Recruitment of postpartum women with prepregnancy diabetes.

Initially identified as eligible (n = 88)	Unable to contact (n=10)[a] Perinatal loss or serious malformation (n=10)
↓	
Approached (n = 68)	Did not respond (n=21) Declined to participate (n=1) Expressed interest but did not sign consent before 8 weeks postpartum (n=2)
↓	
Consented (n = 44)	Did not complete survey (n=4)
↓	
Primary Outcome Analyzed (n = 40)	

[a]We initially had IRB approval to approach women in person, and in that time, we were unable to contact women because they did not attend their postpartum appointment. After we obtained IRB approval to contact women by phone or email, we were able to reach out to women regardless of appointment attendance, but were unable to contact women who did not respond to email, texts, or calls (n=10). Women were not contacted if nurses providing their care instructed us not to approach them or there were instructions in their electronic health record not to approach them.

Table 4.1. Demographic and diabetes characteristics of postpartum women with prepregnancy diabetes (n = 40).

	Total	Procedure /prescription	Non-Prescription	None	P
Demographic characteristics					
Age, median (p25-p75)	34.0 (29.0-38.0)	35.0 (30.5-38.5)	32.0 (29.0-35.0)	36.0 (29.0-38.0)	> 0.99
Previous births, n (%)					0.21
No	13 (32.5%)	18 (66.7%)	5 (18.5%)	4 (14.8%)	
Yes	27 (67.5%)	6 (46.1%)	2 (15.4%)	5 (38.5%)	
Race and Ethnicity, n (%)[b]					0.51
Hispanic, any race	9 (22.5%)	6 (66.7%)	3 (33.3%)	0	
Non-Hispanic, Asian	2 (5.0%)	2 (100.0%)	0	0	
Non-Hispanic, Black	13 (32.5%)	5 (38.5%)	1 (7.7%)	7 (53.8%)	
Non-Hispanic, Other or More than One	1 (2.5%)	1 (100.0%)	0	0	
Non-Hispanic, White	15 (37.5%)	10 (66.7%)	3 (20.0%)	2 (13.3%)	
Religion, n (%)					0.16
Catholic	8 (20.0%)	7 (87.5%)	1 (12.5%)	0	
Christian, not Catholic	30 (75.0%)	16 (53.3%)	5 (16.7%)	9 (30.0%)	
None	2 (5.0%)	1 (50.0%)	1 (50.0%)	0	
Educational Attainment, n (%)[b]					0.71
Less than high school	2 (5.0%)	1 (50.0%)	1 (50.0%)	0	
High school graduate	8 (20.0%)	6 (75.0%)	2 (25.0%)	0	
Some college	14 (35.0%)	6 (42.9%)	2 (14.2%)	6 (42.9%)	
College graduate or more	16 (40.0%)	11 (68.8%)	2 (12.5%)	3 (18.7%)	
Health Insurance, n (%)[b]					0.15
Private insurance	23 (57.5%)	16 (69.6%)	3 (13.0%)	4 (17.4%)	
Medicaid	9 (22.5%)	3 (33.3%)	2 (22.2%)	4 (44.4%)	
None/Don't Know	8 (20.0%)	5 (62.5%)	2 (25.0%)	1 (12.5%)	
Diabetes Characteristics					
Age at diagnosis, median (p25-p75)	26.5 (17.5-32.0)	25.5 (16.0-31.5)	31.0 (20.0-33.0)	26.0 (20.0-35.0)	0.31
Years since diagnosis, median (p25-p75)	8.0 (2.0-12.5)	8.0 (3.0-17.5)	2.0 (0.0-9.0)	10.0 (2.0-12.0)	0.14
Type of diabetes, n (%)					0.20
Type 1 (T1DM)	10 (25.0%)	8 80.0%)	1 (10.0%)	1 (10.0%)	
Type 2 (T2DM)	30 (75.0%)	16 (53.3%)	6 (20.0%)	8 (26.7%)	

[a] Tests of association compared bivariate association of demographic characteristics with use of procedure/prescription contraception versus non-prescription/no contraception. Categories were also collapsed because of sample size limitations for demographic characteristics where indicated.

Non-parametric Wilcoxon test was used for all continuous variables. We used $\chi 2$ test for categorical variables where at least 25% of cells had a cell count above 5 (parity and race/ethnicity), and Fisher's Exact Test was used for all other categorical variables.

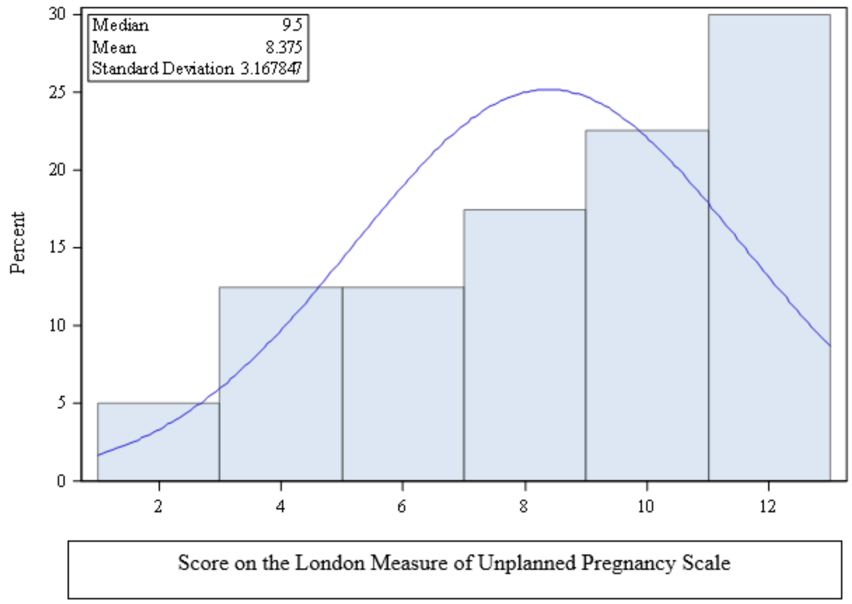
[b] For tests of association, demographic characteristics collapsed into 2-level categories for race and ethnicity ("Non-Hispanic White" or "Not Non-Hispanic White"), insurance ("Has private insurance" or "Does not have private insurance"), and education ("High School graduate or less" or "Some college or more").

Table 4.2. Behaviors, beliefs and attitudes of postpartum women with prepregnancy diabetes (n = 40).

Behaviors	**Total**	**P**
Has had sex since the delivery, n (%)	20 (50%)	0.52
When sex resumed after delivery, median (p25-p75)[b]	5.0 (4.0-5.5)	0.49
Frequency of sex was once a week or less, n (%)[b]	19 (95%)	0.52
Any contraceptive use, n (%)		N/A
Contraceptives always used	29 (72.5%)	
Contraceptives sometimes but not always used	2 (5.0%)	
Contraceptives never used	9 (22.5%)	
Most effective method used, n (%)		N/A
Procedure/prescription	24 (60.0%)	
Non-Prescription	7 (17.5%)	
None	9 (22.5%)	
Beliefs and attitudes		
Want to be pregnant again ever, n (%)	9 (22.5%)	0.94
Wants to be pregnant again, n (%)[c]		0.99
Within 18 months	1 (11.1%)	
18 months-2 years	1 (11.1%)	
2-5 years	6 (66.7%)	
More than 5 years	1 (11.1%)	
Thinks about diabetes when making decisions about birth control, n (%)	15 (37.5%)	0.32
Believes diabetes caused complications/problems in recent pregnancy, n (%)	22 (55.0%)	0.75
Believes birth control is less safe for women with diabetes, n (%)	5 (12.5%)	> 0.99
Believes birth control is less effective for women with diabetes, n (%)	14 (35.0%)	0.79
Believes women with diabetes need birth control less than other women, n (%)[d]	2 (5.1%)	> 0.99
Believes diabetes makes it harder for women to get pregnant, n (%)	14 (35.0%)	> 0.99
Diabetes management was part of preconception care for index pregnancy, n (%)	7 (17.5%)	0.68
London Measure of Unintended Pregnancy, median (p25-p75)[d]	9.5 (6.0-11.0)	0.18
RHAB Benefits, median (p25-p75)[d]	16.0 (13.0-18.0)	0.03
RHAB Barriers, median (p25-p75)[e]	5.0 (4.0-8.0)	0.20
RHAB Self-Efficacy, median (p25-p75)	49.0 (40.0-56.0)	0.32

[a] Tests of association with using procedure/prescription contraception vs otherwise.
[b] Among the 20 women who have had sex since the delivery.
[c] Among the 9 women who want to become pregnant again.
[d] Missing data for n=1
[e] Missing data for n=2

Figure 4.2. Distribution of scores on London Measure of Unplanned Pregnancy among postpartum women with prepregnancy diabetes (n = 39).



Higher scores indicated the pregnancy was more intended.

Figure 4.3. Most effective contraceptive method used by women with prepregnancy diabetes between 4-8 weeks postpartum (n = 40).

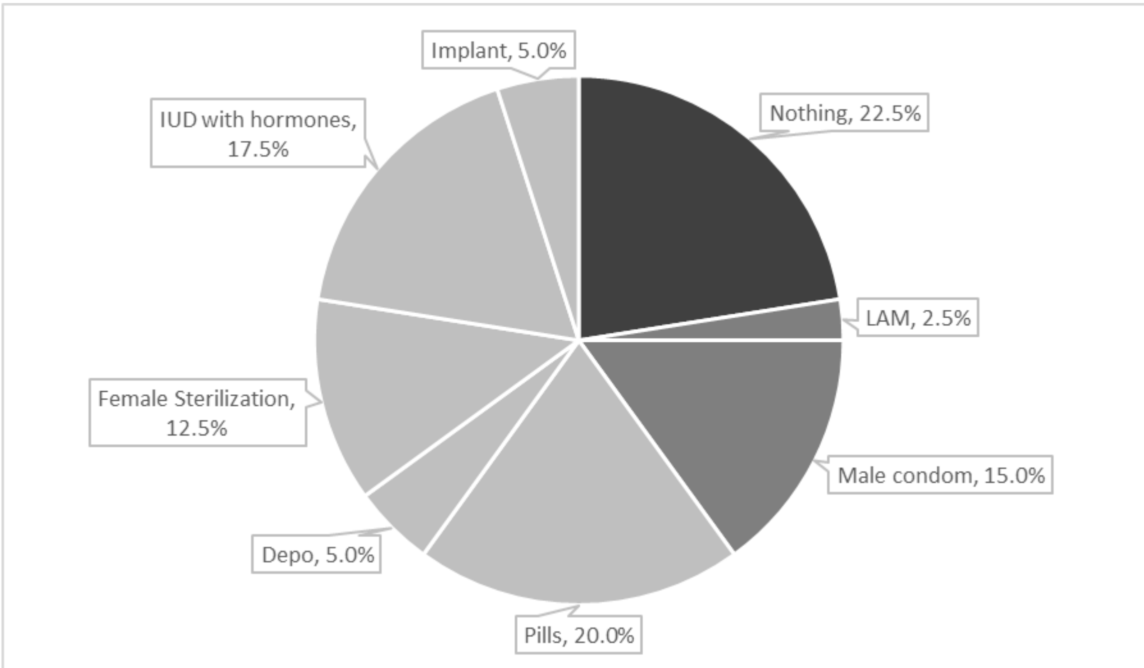


Table 4.3. Odds of using procedure/prescription contraception associated each additional ½ standard deviation increase in contraceptive attitudes among women with prepregnancy diabetes.

	Odds of using procedure/prescription contraception[a]	**Adjusted odds of using procedure/prescription contraception[b]**
RHAB Benefits[c]	1.53 (1.02-2.27)	1.73 (1.05-2.84)
RHAB Barriers[d]	1.19 (0.86-1.65)	1.17 (0.82-1.70)
RHAB Self-Efficacy[e]	0.85 (0.61-1.18)	1.002 (0.64-1.57)

[a] Scaled to represent the change in odds ratio for an increase in the score equivalent to the value of one-half standard deviation for that scale.
[b] Adjusted for age, race and ethnicity, educational attainment, insurance, type of diabetes, whether this was their firstborn child, intendedness of index pregnancy, and whether they had resumed sexual activity since delivery.
[c] N=39
[d] N=40
[e] N=38

CHAPTER 5: SYNTHESIS

Introduction

The objective of this dissertation was to generate knowledge about women with diabetes and their reproductive lives. The Aim 1 manuscript (second chapter) was focused on estimating the prevalence of diagnosed diabetes, undiagnosed diabetes, total diabetes (both diagnosed and undiagnosed diabetes), suboptimal preconception glycemic control, and prediabetes among women of reproductive age by race and ethnicity. The Aim 2 manuscript (third chapter) was focused on distinguishing the effectiveness of contraception used by women with diagnosed diabetes, undiagnosed diabetes, and prediabetes. The hypothesis was tested that women with diabetes would be less likely to use contraception than their normoglycemic peers, controlling for demographic characteristics and body mass index (BMI). The Aim 3 manuscript (fourth chapter) was focused on describing the behaviors, beliefs, and attitudes of postpartum women with preconception diabetes toward using contraception, including their perception of the benefits, barriers, and self-efficacy related to contraception use. The hypothesis was tested that women with greater perception of benefits, lower perception of barriers, and greater self-efficacy would have greater odds of using prescription contraception.

The primary findings of the Aim 1 manuscript were that the prevalence of total diabetes, prediabetes, suboptimal preconception glycemic control, and lacking a diagnosis differed by race and ethnicity. The highest rates of each were evident among non-Hispanic black women and Hispanic women. The primary findings of the Aim 2 manuscript were that women with diabetes had higher odds of using no contraception, rather than more effective contraception, compared to women with normoglycemia. The primary findings of the Aim 3 chapter were that prescription contraceptive use increased when women had a greater perception of the benefits of contraceptive use and preconception care.

Theoretical Grounding

The findings of this dissertation are best viewed through the lens of the theories grounding the dissertation. Brown et al.'s Socioeconomic Position and Health among Persons with Diabetes Mellitus theoretical framework (Brown et al., 2004) and Pender's Revised Health Promotion Model (Pender, 2011) have been integrated in Figure 1.1.

When combined, these frameworks position both demographic characteristics and attitudes as potential antecedents to a health behavior of interest, which was originally specified as non-use of effective contraception by women with diabetes when not seeking pregnancy. Use of effective contraceptive methods is a strategy for preventing unintended pregnancies during periods of suboptimal preconception glycemic control during which fetal exposure to elevated blood glucose increases risk of adverse obstetrical outcomes (Berry et al., 2016; Galindo et al., 2006; Kitzmiller et al., 2010; Wahabi et al., 2010). The findings of the three manuscripts will be discussed generally and then using both types of constructs in the model, sociodemographic factors and attitudes, which are theorized to precede contraceptive use by women with diabetes.

Primary Findings

Diabetes Prevalence

In the Aim 1 manuscript, 6.8% of United States (U.S.) women aged 24-32 had diabetes and 21.8% had prediabetes. This indicates a higher prevalence than reported in the 2011-2014 National Health and Nutrition Examination Survey (NHANES), which was that 2.6% men and women aged 18-44 years old had diagnosed diabetes, 1.3% had undiagnosed diabetes, and 4.0% had total diabetes (referring to the aggregation of both diagnosed and undiagnosed diabetes) (Centers for Disease Control and Prevention (CDC), 2017).

Data from the NHANES is routinely used to generate the CDC's statistics about diabetes (CDC, 2017). In the CDC's National Diabetes Statistics Report, as well as much of the literature also drawing on NHANES, it is typical practice to report diabetes prevalence data by age group (18−44 years, 45−64 years, and 65 years and above), gender, and race and ethnicity (CDC, 2017; Cowie et al., 2009; Geiss et al., 2014; Menke et al., 2015). This dissertation stratified by gender, race and ethnicity, and age simultaneously in order to understand how diabetes prevalence may affect pregnancy at the population level.

In the years when Wave IV data of Add Health was collected (primarily in 2008), the U.S. total diabetes prevalence was 12.5% among all adults aged 20 or older (Menke et al., 2015). Since diabetes prevalence increases with age, we would expect prevalence estimates for women aged 24-32 to be lower than estimates for all adults or even the subset between ages 18-40 years old (Menke et al., 2015). However, among adults aged 20-44 in 2007-2008 in NHANES, total diabetes prevalence was 3.7% (Menke et al., 2015), which is 3.1 percentage points lower than what we observed among women aged 24-32 in Add Health (6.8%) (Britton, Hussey, Crandell, et al., 2018). Our estimates may have been slightly higher because we included women who used medications for diabetes, unlike Menke and colleagues (2015). Our findings were consistent with the observation that Add Health produced higher estimates of diabetes prevalence than NHANES. It is unclear why these differences exist. It may be related to the fact that there were differences in sampling and blood specimen protocols (Bellatorre, 2014; Nguyen et al., 2014).

Diabetes prevalence has increased over the past decade (Menke et al., 2015). From 2011−2014, 12.2% of adults 18 years or older had diabetes with 9.3% diagnosed and 2.9% undiagnosed (CDC, 2017). Between 1990−2008, diabetes prevalence grew sharply with a 4.5% annual percentage increase, and then leveled off between 2008−2012 (Geiss et al., 2014). In part, it was expected the diabetes prevalence would continue to increase secondary to the rise in obesity, a major diabetes risk factor, which significantly increased between 2007−2008 and 2015−2016 (35.4% vs 41.1%) (Hales, Fryar, Carroll, Freedman, & Ogden, 2018). An opportunity to assess the change in diabetes prevalence through the lifespan will be available when Add Health Wave V data is released when participants will be 32−44 years old. However, this will not identify a period effect (2007−2008 vs 2017−2018). That would require a new sample of 24−32 year olds.

It is clinically meaningful that a greater portion of women with diabetes aged 24−32 in Add Health were undiagnosed in comparison to all adults age 20 or older in NHANES (45.3% vs 23.8%) (Britton, Hussey, Crandell, et al., 2018; CDC, 2017). Without a diagnosis, women cannot be identified as appropriate recipients of diabetes-specific preconception care. Women with suboptimal preconception glycemic control (A1C $\geq$ 6.5%) are also a priority since they would be at elevated risk of adverse obstetrical outcomes if they conceived. Younger age at diagnosis is associated with worse glycemic control, having a comorbidity, and lower self-reported overall health status (Ali et al., 2012; Berkowitz, Meigs, & Wexler, 2013; Casagrande et al., 2013; Juarez et al., 2012). We estimated that 51.0% of women aged 24-32 with diabetes have a glycated hemoglobin (A1C) above the American Diabetes Association (ADA)'s recommended preconception level. Notably, 74.7% of women whose diabetes was undiagnosed surpassed that threshold, which was significantly higher than among women with diagnosed diabetes (31.5%) (Britton, Hussey, Crandell, et al., 2018). It is worrisome that women of reproductive age face a greater risk of poor glycemic control while being vulnerable to particular pregnancy-specific complications.

We would expect to see a growing number of pregnancies affected by preconception diabetes if a growing number of women have diabetes during their reproductive years. Two studies confirm this increase. The age-standardized prevalence of preconception diabetes increased from 6.5 to 8.9 per 1000 deliveries from 2000 to 2010 (Bardenheier et al., 2015). Similarly, between 2005 and 2014, the weighted adjusted national estimates of diabetes per 1,000 deliveries increased significantly from 8.6 to 10.3 (Admon et al., 2017). Both studies are consistent with our findings that diabetes is increasingly common among women who are in the phase of life when they can become pregnant.

Contraceptive Use

Our primary findings from the Aim 2 manuscript were that 37.6% of women with diabetes used more effective contraception, 33.6% used less effective contraception, and 28.8% used none. Women with diabetes can lower their risk of pregnancy complications using contraception to assure that glycemic control is achieved before pregnancy (ADA, 2018; Correa et al., 2008; Cyganek et al., 2011; Kjos, 2007; Wahabi et al., 2012). By definition, pregnancy is less likely for sexually active women using more effective contraception (Hatcher et al., 2018). In the general population, 85 of 100 sexually active women using no contraception will become pregnant after a year; this is often called the typical pregnancy rate (Hatcher et al., 2018). Use of contraception can lower the pregnancy rate dramatically: 12−28 out of 100 women who use a less effective method of contraception (such as a spermicide, fertility awareness-based methods, withdrawal, sponge, condoms, or diaphragm) will typically become pregnant after a year, as will 0.05−9 of 100 women who use a more effective method of contraception (such as combined hormonal methods, including the pill, patch, and ring, and depot medroxyprogesterone acetate (also called Depo Provera, Depo, or DMPA; called DMPA in this dissertation) injections; intrauterine devices (IUDs, including Paragard, Mirena, Liletta, Skyla, and Kyleena), contraceptive implants (including Neplanon and Implanon), and female or male sterilization) (Hatcher et al., 2018). The ethical position of this dissertation is not to be directive about which contraception women 'should' use, but instead, to initiate a program of research to improve preconception service delivery, which includes contraception, to women who want it, and who are at risk of medically complicated unintended pregnancies without it.

Statistics about contraceptive use in the U.S. are often generated from the National Survey of Family Growth (NSFG), a survey conducted by the CDC (Daniels et al., 2015). In the 2006−2010 NSFG, 37.8% of women aged 15-44 used no contraception; unlike our sample, NSFG includes women who were pregnant, trying to become pregnant when data was collected, or not sexually active with male partners. Nationally, only 7.7% of the total population was at risk of unintended pregnancy and not using contraception (Daniels et al., 2015). It was not possible to specify who was at risk of unintended pregnancy in Add Health because women's intentions were not queried. Nationally, 48.2% of women used more effective methods, which constituted 77.0% of contraception users. Similarly, in our sample of women aged 24−32, 55.2% used more effective methods, which constituted 67.4% of the contraception users (Daniels et al., 2015). In contrast, 37.6% of women with diabetes in the Aim 2 analysis used more effective methods, which constituted 52.8% of contraception users with diabetes.

Among sexually active women with diabetes aged 24-32, almost one out of three used no contraception in the preceding year (28.8%), which was significantly greater than the percentage among women with normoglycemia (16.4%) (Britton, Hussey, Berry, et al., 2018). Among postpartum women with diabetes, a total of 22.5% were not using any contraception in the four to eight week period after delivery (Britton, Berry, et al., 2018). Women with diabetes who are not effectively preventing pregnancy need patient-centered reproductive health care, whether that be contraceptive services, preconception care, or both.

In previous studies, rates of contraception non-use ranged from 25.8-38.8% for non-postpartum women with diabetes (Chuang et al., 2005; Vahratian et al., 2009) and 23%-48% for postpartum women with diabetes (Perritt et al., 2013; Schwarz et al., 2017). The wide ranges are due, in part, to variations in data sources and sampling, which we discuss below.

Vahratian et al. (2009) found that 38.8% of women aged 20-44 with diagnosed diabetes used no contraception in the nationally representative 2002 NSFG (Vahratian et al., 2009). In the 2000 Behavioral Risk Factor Surveillance System (BRFSS) from 11 states, Chuang et al. (2005) found that 25.8% of women aged 18-44 with diagnosed diabetes did not use contraception (after excluding women who were trying to become pregnant) (Chuang et al., 2005). Schwarz et al. (2017) found that 48% of postpartum women with diagnosed diabetes enrolled in California's Medi-Cal did not submit a claim in 2012 for contraception in the 43 days before or 99 days after giving birth (Schwarz et al., 2017). Perrit et al. (2013) found that 23% of postpartum women surveyed in the 2004-2007 Maryland Pregnancy Risk Assessment Monitoring System (PRAMS) reported they were not using contraception (Perritt et al., 2013).

Both Schwarz et al. (2015) and Perritt et al. (2013) found that postpartum women with preconception diabetes had a significantly higher odds of not using contraception, compared to their peers without diabetes (Perritt et al., 2013; Schwarz, Barr, Cross Riedel, Howell, & Thiel de Bocanegra, 2015). We did not do comparison testing between postpartum women with and without diabetes in the Aim 3 paper (Britton, Berry, et al., 2018), but we did find that non-postpartum women with diabetes had significantly higher odds of contraception non-use than their peers without diabetes in the Aim 2 paper (Britton, Hussey, Berry, et al., 2018). The findings in this dissertation were inconsistent with previous research, in which no differences were seen in contraceptive use between non-postpartum women with and without diabetes (Chuang et al., 2005; Vahratian et al., 2009). This difference may have been produced because we included women with undiagnosed diabetes. We also note previous studies have not queried the effectiveness of methods used by women with diabetes, so we have no point of comparison for those findings from the Aim 2 analysis.

Other Characteristics

We will next discuss the findings related to exogenous characteristics theorized to influence the health behavior of interest directly as well as indirectly, through attitudes, based on the integrated theory underlying this research (Figure 1.1). In the following sections, the findings regarding non-Hispanic black race and ethnicity, Hispanic ethnicity, socioeconomic position (SEP), and BMI will be discussed. In our Aim 3 analysis, race and ethnicity and SEP were measured but not significantly associated with contraceptive use in bivariate tests or as covariates in multiple regression models. This study did not have an adequate sample size to explore those relationships. BMI was not measured in the Aim 3 study.

In the Aim 1 analysis, we were able to address the aforementioned gap in the literature and distinguish differences in diabetes characteristics by race and ethnicity for non-Hispanic black women, Hispanic women, and Asian women in comparison to non-Hispanic white women. Most results for Native American women were suppressed in compliance with the Add Health policies to prevent deductive disclosure because cell counts were less than five.

Non-Hispanic black women exhibited the highest prevalence of prediabetes (38.5%) and total diabetes (15.0%) among any racial or ethnic group of U.S. women aged 24−32 (Britton, Hussey, Crandell, et al., 2018). Compared to non-Hispanic white women, non-Hispanic black women had 3.7 times the odds of having prediabetes and 4.8 times the odds of having diabetes. Our findings were similar to the 2011−2014 NHANES in the 2017 National Diabetes Statistics Report in that non-Hispanic black adults exhibited a higher prevalence of total diabetes than any other racial or ethnic group (CDC, 2017). Among non-Hispanic black adults aged 18 or older, the prevalence of prediabetes was 36.3%, and total diabetes was 17.7% and the prevalence of diagnosed diabetes, specifically among women, was 13.2% (CDC, 2017). It was surprising that these values were close to what we observed since we would expect the NHANES sample, containing older adults, to have a much higher rate of diabetes, reflecting the tendency mentioned above for the Add Health methodology and sample to identify higher diabetes prevalence.

If diabetes were increasing among non-Hispanic black women of reproductive age, we would expect to see a corresponding increase in preconception diabetes during their pregnancies. For non-Hispanic black women, the age-standardized rate of preconception diabetes per 100 births increased from 1.01 to 1.27 between 2000−2010; both the rate and the absolute increase in rate were greater than for non-Hispanic white women, among whom the rate increased from 0.56 to 0.72 (Bardenheier et al., 2015).

Of the non-Hispanic black women with diabetes, 75.6% were undiagnosed, with 11.2 times the odds of having diabetes without a diagnosis in comparison to non-Hispanic white women. In contrast, among all adults over age 18 with diabetes, only 24.8% of non-Hispanic black adults with diabetes were undiagnosed, and 21.5% of non-Hispanic white with diabetes were undiagnosed (no hypothesis testing was performed) (CDC, 2017). The undiagnosed rate for non-Hispanic white adults aged 20 or older (23.5%) was closer to the rate we found among non-Hispanic white women aged 24-32 (22.8%). It is beyond the scope of this study to explain why we found a statistically significant difference by race and ethnicity in undiagnosed rates among women aged 24−32. This question warrants future research.

Non-Hispanic black women with diabetes also exhibited 15.6 times the odds of having suboptimal preconception glycemic control in comparison to non-Hispanic white women, with 88.2% having an A1C $\geq$ 6.5%. Our findings are consistent with the higher rates of elevated blood glucose and sequelae secondary to elevated blood glucose experienced by non-Hispanic black adults through the lifespan (Lanting et al., 2005). In an analysis of the 2007−2010 NHANES, the age-adjusted prevalence of A1C > 9% was significantly higher among non-Hispanic black adults than non-Hispanic white adults (17.6% vs 9.7%) (Ali et al., 2012). In a literature review of 51 studies about diabetes complications, ethnic minorities experienced higher rates of elevated blood glucose, complications secondary to elevated blood glucose, and diabetes-related mortality (Lanting et al., 2005). While some differences were attenuated by adjustments for demographic and behavioral factors, the elevated risks of retinopathy, end-stage renal disease, and lower quality of diabetes care for non-Hispanic black adults were undiminished (Lanting et al., 2005). Since non-Hispanic black women are disparately exposed to elevated blood glucose, we would expect to see a disparity in pregnancy complications between non-Hispanic white women with diabetes and non-Hispanic black women with diabetes. In the general population, non-Hispanic black women disproportionately experience fetal demise, preterm birth, and low birth weight (Bryant et al., 2010). However, less is understood about the epidemiology of diabetes-related pregnancy complications. Many of the key studies about diabetes and pregnancy were conducted in Europe where the health of non-Hispanic black women does not have the same historical context as in the U.S. (Cyganek et al., 2011; Evers, 2004; Köck, Köck, Klein, Bancher-Todesca, & Helmer, 2010; Roberts, 1997; Timar et al., 2014). Nonetheless, the combined evidence that non-Hispanic black women experience a higher prevalence of elevated A1C and lower quality of care (Lanting et al., 2005) raises concerns that non-Hispanic black women with diabetes may have worse perinatal outcomes than non-Hispanic white women with diabetes.

Women can use contraceptives to minimize the likelihood of pregnancy while their A1C is high. However, only approximately half of pregnancies in the U.S. are planned (55%) (Finer & Zolna, 2016). In 2008, a greater percentage of pregnancies to non-Hispanic black women were unintended compared to non-Hispanic white women (69% vs 42%) (Finer & Zolna, 2016), and non-Hispanic black women in the general population at risk of unintended pregnancy were more likely to use no contraception than their non-Hispanic white peers (24.8% vs 14.3%, $p < 0.001$) (Mosher et al., 2015). In contrast, in our Aim 3 sample, more non-Hispanic white women used no contraception than non-Hispanic black women. We did not see differences in contraception non-use between non-Hispanic black women with diabetes and non-Hispanic white women with diabetes. However, when all races and ethnicities were aggregated, women with diabetes were more likely to use no contraception than women without diabetes (Britton, Hussey, Berry, et al., 2018) and non-Hispanic black women were more likely to have diabetes and an elevated A1C (Britton, Hussey, Crandell, et al., 2018), suggesting that this is an important population to involve in family planning intervention development striving to reduce fetal exposure to elevated blood glucose.

We also noted that both non-Hispanic black women (as well as Hispanic women) were significantly more likely to use less effective contraception than more effective methods (Britton, Hussey, Berry, et al., 2018). The prevalence of less effective contraceptive use raises questions about the sufficiency of family planning services. If avoiding pregnancy is important to a woman, less effective methods may not meet her needs (Sundaram, Harman, & Cook, 2014). Some women may use less effective methods because more effective methods are inaccessible. However, women may value the characteristics of the less effective methods, including lack of hormones, personal control, lack of influence on their menstrual period, and with barrier methods, the most commonly used less effective method, protection against sexually transmitted infections (Daniels et al., 2015; Gilliam & Hernandez, 2007; Higgins, Ryder, Skarda, Koepsel, & Bennett, 2015; Jackson et al., 2016). Although effectiveness is not the only characteristic that matters to women, contraceptive counseling may suggest to women considering the tradeoffs that they consider giving more weight to effectiveness if they are concerned about their blood glucose elevating the risk of adverse pregnancy outcomes.

Among Hispanic women of any race, 64.7% were normoglycemic, 27.8% had prediabetes, and 7.5% had diabetes (Britton, Hussey, Crandell, et al., 2018). Hispanic women had greater odds of prediabetes (adjusted odds ratio [aOR] 1.3, 95% confidence interval [CI] 1.4-2.5) and diabetes (aOR 1.7, 95% CI 1.7, 95% CI 1.2-2.5) compared to non-Hispanic white women. Of the Hispanic women with diabetes, 48.1% were undiagnosed, and 42.9% had suboptimal preconception glycemic control, but the odds did not differ significantly from those of non-Hispanic white women in the multivariate model. In 2017, the total prevalence of diabetes among Hispanic adults in the U.S. was 16.4%, with 4.5% undiagnosed and 11.9% diagnosed (CDC, 2017). Among Hispanic women, the prevalence of diagnosed diabetes was 11.7%, and variation was evident by nationality, ranging from 5.9% among women of Cuban origin to 13.5% among women of Mexican origin (CDC, 2017). Because Add Health participants are younger than NHANES participants, we expected to see lower rates of diabetes in our sample, which we did (7.5% vs 16.4%) (Britton, Hussey, Crandell, et al., 2018; CDC, 2017). As with non-Hispanic black women, we found higher rates of undiagnosed diabetes among Hispanic women aged 24-32 in Add Health than among Hispanic adults aged 20 and above in NHANES (48.1% vs 27.4%) (Britton, Hussey, Crandell, et al., 2018; CDC, 2017).

We expected an increase in diabetes among women of reproductive age to correspond to an increase in diabetes among women who were pregnant, and between 2000-2010, the percentage of deliveries with pre-pregnancy diabetes increased among women of all race and ethnicities (Bardenheier et al., 2015). Among Hispanic women, the percentage having births with pre-pregnancy diabetes rose from 0.74 to 0.94 between 2000-2010, which was higher than the rates among non-Hispanic white women (0.56 to 0.72 between 2000-2010) (Bardenheier et al., 2015).

In Aim 2, Hispanic women had greater odds of using less effective contraception rather than more effective contraception in comparison to non-Hispanic White women (aOR 1.39, 95% CI 1.02−1.90) (Britton, Hussey, Berry, et al., 2018). If the use of any contraception suggests intent to prevent pregnancy, popularity of less effective methods is concerning because of higher failure rates (Sundaram et al., 2014). Hispanic women have a higher unintended pregnancy rate than non-Hispanic white women (56% vs 42%) (Finer & Zolna, 2016), but when at risk of unintended pregnancy, contraception non-use occurs at similar rates (Mosher et al., 2015). When we modeled contraceptive use in the general population, we saw no difference between contraceptive non-use between Hispanic women and non-Hispanic White women (Britton, Hussey, Berry, et al., 2018). However, within the subpopulation of women with diabetes, Hispanic women had greater odds of using less effective contraception (aOR 2.70, 95% CI 1.01−7.19) and lower odds of using no contraception (aOR 0.20, 95% CI 0.05−0.72) rather than more effective contraception in comparison to non-Hispanic White women (Britton, Hussey, Berry, et al., 2018). Since some evidence suggests that Hispanic adults with diabetes receive lower quality care (Lanting et al., 2005), future research should address whether Hispanic women with diabetes are using less effective contraceptive methods, which do not require a prescription or an office visit, because they are not receiving high quality family planning care.

The Census Bureau has estimated that the Hispanic population will increase from 17.8% to 27.5% of the population between 2016 and 2060. Although our findings suggest that the diabetes disparities are more severe between non-Hispanic black and non-Hispanic white women, diabetes also affects the rapidly growing Hispanic community. The expected demographic shifts underscore the importance of assuring that innovations in integration of family planning and diabetes management meet the needs of Hispanic women.

Fewer Asian women had diabetes than non-Hispanic white women (4.5% vs 4.8%), and a smaller percentage of the Asian women with diabetes were undiagnosed (11.4% vs 22.8%) or had suboptimal preconception glycemic control (18.1% vs 26.3%) in comparison to non-Hispanic white women. Our findings did not reflect the disparities observed when all adults are aggregated in the 2011−2012 NHANES, where Menke et al. found that 20.6% of Asians had diabetes and of whom 50.9% were undiagnosed, in comparison to 11.3% of non-Hispanic white adults, of whom 36.8% were undiagnosed (Menke et al., 2015). In the 2011−2014 NHANES data, 10.3% of Asian women had diagnosed diabetes and 5.7% had undiagnosed diabetes. As among Hispanic women, heterogeneity was evident among Asians, and the rate of diagnosed diabetes ranged from 2.8% for Chinese women, to 8.9% for Filipino women, and 10.0% for Asian Indian women (CDC, 2017).

Asian women were significantly more likely to have prediabetes than normoglycemia than non-Hispanic white women in the multivariate model (25.1% vs 16.6%; aOR 1.8, 95% 1.2-2.6) (Britton, Hussey, Crandell, et al., 2018). Our findings were more consistent with the trends among all adults aged 18 or older, where prediabetes prevalence was higher among Asian adults than non-Hispanic white adults (35.7% vs 31.5%, with 95% confident intervals not overlapping) (CDC, 2017). Prediabetes indicates an elevated risk of developing T2DM (ADA, 2018). It is important to note that the ADA has recommended that Asian adults be tested for prediabetes at a lower BMI threshold than adults of other races (> 23kg/m2 vs > 25 kg/m2) (ADA, 2018).

Guided by Brown's (2004) Socioeconomic Position and Health among Persons with Diabetes Mellitus, we included educational attainment, type of health insurance, and self-reported access to healthcare in our multivariate models to assure socioeconomic characteristics did not explain away the relationship between race and ethnicity and diabetes (Britton, Hussey, Crandell, et al., 2018) and between diabetes and contraceptive use (Britton, Hussey, Berry, et al., 2018).

Women who reported lacking access to care were more likely to have diabetes than be normoglycemic, but insurance was not a significant predictor of diabetes status (Britton, Hussey, Crandell, et al., 2018). Surprisingly, neither insurance nor access was significant in the multivariate models of diagnosis status or glycemic control (Britton, Hussey, Crandell, et al., 2018). In particular, we expected that insurance would be associated with glycemic control since diabetes management is expensive without coverage (Gaskin et al., 2014; Saydah et al., 2012). In the 2007-2010 NHANES, significantly more uninsured adults with diabetes had an A1C > 9% than adults with diabetes who used private insurance (20.7% vs 9.5%), but neither group was significantly different from adults with diabetes who use Medicaid (Ali et al., 2012).

Adults with diagnosed diabetes who lacked insurance were less likely than those with insurance to obtain diabetes preventive care services, including A1C testing, foot examinations, eye examinations, blood cholesterol checks, influenza vaccines, and blood pressure checks (Brown et al., 2004). If preconception care and family planning are conceptualized as preventative care for women with diabetes, then we would expect insurance and access to be associated with the more effective contraceptive methods, which require a prescription or procedure.

We found that women without insurance had greater odds of using less effective contraception than women with private insurance, but specifically among women with diabetes, insurance had no association with the effectiveness of the contraceptive method used (Britton, Hussey, Berry, et al., 2018). Women without insurance are less likely to use prescription contraceptive methods than women with insurance (Culwell & Feinglass, 2007). Surprisingly, when the Patient Protection and Affordable Care Act increased the insurance coverage for women of reproductive age, the expected increase in prescription methods was not seen (Kavanaugh & Jerman, 2018). The effect of being uninsured may be attenuated by Title X family planning clinics, which provide contraception on a sliding scale for women who meet income requirements.

Lacking access to care was associated with the use of less effective contraception, but not use of no contraception, in the general population; however, there were no associations between contraception and access among women with diabetes (Britton, Hussey, Berry, et al., 2018). Insurance alone does not confer access to desired contraceptive methods if women encounter other barriers, including the cost of copays, deductibles, transportation to the appointment, time away from work, and poor quality care by healthcare workers without the knowledge, skill, willingness, and supplies to provide respectful and unbiased counseling, education and services (Lamme, Edelman, Padua, & Jensen, 2017; McLemore et al., 2018). The single item used in Add Health to query women's perceptions of access to care may have been inadequate to measure such a complex construct.

Lower education attainment was associated with greater odds of having diabetes rather than being normoglycemic (Britton, Hussey, Crandell, et al., 2018), in line with evidence that lowest education attainment has been associated with lower age of type 2 diabetes onset (Berkowitz et al., 2013). However, education was not significantly associated with suboptimal preconception glycemic control, similar to findings in the 2007−2010 NHANES that prevalence of A1C > 9% among adults with diabetes did not vary by education (Ali et al., 2012).

Lower education attainment was associated with using less effective contraception or no contraception rather than more effective contraception in the general population, but not in the subpopulation of women with diabetes (Britton, Hussey, Berry, et al., 2018). Some studies have found that contraceptive non-use decreases with educational attainment (Jacobs & Stanfors, 2013), while others have observed a curvilinear relationship, where non-use was more likely among women with some college, compared to women with less or more education (Mosher et al., 2015).

Women who have obesity used no contraception or less effective contraception more than women with overweight and women with normal or underweight, in both the general population and our subpopulation with diabetes (Britton, Hussey, Berry, et al., 2018). Women with obesity with diabetes had a distinctly higher odds of being contraceptive non-users. It is important that future research addresses the barriers these women may encounter by virtue of either health issue.

Our findings were similar to trends observed over the last two decades: in the 2000 Behavioral Risk Factor Surveillance System (BRFSS), 23.4% of women with obesity did not use contraception, with significantly greater adjusted odds compared to women with normal weight (Chuang et al., 2005). In the 2002 NSFG, non-sterilized women with obesity whose BMI > 35 kg/m2 had a significantly greater odds of contraception non-use than normal weight women (Vahratian et al., 2009). Among women with obesity who were at risk for an unintended pregnancy in the 2006–2010 NSFG data, 21.5% used no contraceptive method and 47.4% used prescription methods (Callegari et al., 2018). Not using contraception was significantly less likely if the women with obesity had discussed contraception with a provider in the last 12 months (Callegari et al., 2018). More recently, in the 2011–2015 NSFG data, among women at risk of unintended pregnancy, no method was used by 10.2% of women with overweight, 9.3% of women with obesity whose BMI was between 30.0 and 34.9 kg/m2, and 10.2% of women with obesity whose BMI was over 35 kg/m2 (Mosher, Lantos, & Burke, 2017). Compared to women with underweight and normal weight, women with obesity whose BMI was between 30.0 and 34.9 kg/m2 were more likely using female sterilization, and women with obesity whose BMI exceeded 35 kg/m2 were more likely to use sterilization or IUDs (Mosher et al., 2017). Women with overweight did not use different contraception methods than women with underweight or normal weight after covariates (self-rated health, education level, marital status, race and ethnicity, parity, and age) were added to the model (Mosher et al., 2017).

Many reasons have been suggested why women with obesity were less likely to use contraception when not seeking pregnancy. These include provider stereotypes that women with obesity engage in less sexual activity, patient or provider perception that women with obesity have reduced fertility, patients having a comorbid condition that either presents as a contraceptive contraindication or requires additional time by the provider, or obesity coexisting with other demographic factors, such as minority race/ethnicity or lower income, which are associated with less contraceptive access (Edelman, 2009). Notably, one study found no difference in the number of current sexual partners or frequency of sexual activity among women with normal weight, overweight, or obesity (Kaneshiro, Jensen, Carlson, & Harvey, 2008). While women with overweight and obesity may encounter challenges becoming pregnant (Brewer & Balen, 2010; D. C. G. Law, Maclehose, & Longnecker, 2007), reduced fertility may not entirely eliminate a woman's need to use contraception if they desire to avoid unintended pregnancies. In an older study using the 1999 PRAMS data, women with overweight and obesity had almost twice the odds of reporting that their live birth resulted from unintended pregnancy (Huber & Hogue, 2005).

There is limited evidence available with which to address concerns about safety and effectiveness of contraceptive use by women with overweight and obesity, although no methods were contraindicated according to the U.S. Medical Eligibility Criteria for Contraceptive Use (CDC, 2016; Edelman, 2009). In its clinical guidelines, the Society for Family Planning asserts that there is good and consistent scientific evidence that contraception prevents more pregnancies in women at any BMI than non-use (Edelman, 2009). The guidelines also note that limited and inconsistent evidence is available that suggests that oral contraceptives (combined hormonal or progestin-only) may be less effective in women with overweight and obesity; oral contraceptives may be less effective if women have gastrointestinal malabsorption secondary to bariatric surgery; and the risk of venous thromboembolism is small but raised with combined hormonal methods (including pill, patch, and ring) though still less than the risk during pregnancy or postpartum (Edelman, 2009). Combined hormonal contraceptives and DMPA were inaccurately described as "unsafe or very unsafe" for women with obesity by sizeable proportions of family planning providers surveyed about the U.S. Medical Eligibility Criteria for Contraceptive Use (22%-29.5% and 11.1%-22.2% respectively) (Jatlaoui et al., 2017), suggesting a need for improved provider competency in caring for women with obesity.

Women with obesity have expressed concerns about weight gain as a side effect of contraceptives (Chuang et al., 2010) and undesired weight gain can motivate contraceptive discontinuation or non-initiation (Potter, Hubert, & White, 2017; Rosenberg & Waugh, 1998; Westhoff et al., 2007). In the Choice Study, women were significantly more likely to perceive weight gain of at least 5 pounds over the preceding 12 months with the implant and DMPA than the copper IUD, and weight gain was reported by 37% of women with overweight and obesity. Although some evidence suggests that DMPA is associated with weight gain (Beksinska & Smit, 2013), the evidence for other methods is weaker. A systematic review of randomized controlled trials was deemed insufficient to determine if combined hormonal contraceptives caused weight gain (Gallo, Grimes, Schulz, & Helmerhorst, 2004).

Attitudes

While Aims 1 and 2 used a dataset that offered the meaningful capacity to describe population trends in diabetes status and contraceptive use stratified by race and ethnicity, SEP, and BMI, Add Health offered little data about women's subjective experiences. To complement the findings of Aims 1 and 2, we surveyed women with diabetes to address Aim 3. Pender's Revised Health Promotion model suggests that health attitudes can drive health behaviors, so in Aim 3 we used the validated Reproductive Health Attitudes and Behaviors (RHAB) scales (Charron-Prochownik, Wang, et al., 2006) and investigator-developed items to query an array of attitudes and beliefs described in the qualitative literature. In our Aim 3 sample, a high score on the scale measuring perceived benefits of contraceptive use and preconception care was significantly associated with use of procedure/prescription contraception postpartum. Scores on the scales measuring women's self-efficacy and perceived barriers to contraceptive use and preconception care were not significant predictors of postpartum contraceptive use, differing from previous research (Grady & Geller, 2016; Komiti et al., 2013; Wang et al., 2006). The difference may have arisen because the RHAB scales were originally validated for use in non-pregnant adolescents with T1DM and we used them with adult women with either T1DM or T2DM ages 21-44 who were postpartum.

We lacked the power to stratify differences in attitudes based on characteristics in Aim 3. However, towards the goal of reducing fetal exposure to elevated blood glucose, a synthesis of the findings from Aims 1 and 2 suggests that non-Hispanic black, Hispanic women, and women with obesity are at-risk populations to involve in intervention development and the use of more effective contraception may be a modifiable health behavior which could support women who want to time pregnancies to periods of better glycemic control. Furthermore, the findings from Aim 3 suggest that even when planning pregnancies, many women are not striving to improve glycemic control before conception. Despite the relative importance of a positive attitude toward contraceptive benefits, women may not see the ability to time pregnancies to periods of optimal health as a benefit.

Chapter Summary

This dissertation synthesizes findings from three Aims. The goal of Aim 1 (second chapter) was to estimate the racial and ethnic differences in the prevalence of total diabetes (both diagnosed and undiagnosed diabetes) and prediabetes among women of reproductive age, as well as suboptimal preconception glycemic control and being undiagnosed among women who have diabetes. We found the highest rates of total diabetes, prediabetes, having diabetes without a diagnosis, and having suboptimal preconception glycemic control among non-Hispanic black women. In Aim 2 (third chapter), the goal was to determine whether women with diabetes were using more effective contraception, less effective contraception, or no contraception at similar rates as their peers with normoglycemia. We found support for the hypothesis that women with diabetes would be more likely to use no contraception than their normoglycemic peers, controlling for demographic characteristics and BMI. In Aim 3 (fourth chapter), the goal was to test whether the postpartum contraceptive use of women with diabetes varied based on their attitudes. Women with diabetes who had greater perception of benefits had greater odds of using procedure/prescription contraception in the postpartum period.

Future Research

This dissertation highlights the potential unmet contraceptive need among women with diabetes, both in young adulthood and the postpartum period. It was beyond the scope of this study to identify the best strategies for improving service delivery and contraceptive uptake. Future research can build on these findings toward the ultimate goal of reducing fetal exposure to elevated blood glucose that can occur with unintended pregnancies at times of poor glycemic control.

Since Aim 1 identified racial and ethnic disparities in total diabetes, prediabetes, undiagnosed diabetes, and suboptimal preconception glycemic control, next steps will be to establish a planning group of non-Hispanic black and Hispanic women of reproductive age and to build relationships with community-based organizations (CBOs) that serve them. Aim 2 also suggested the importance of focusing on women with obesity. Stakeholder engagement with women in these groups will promote identification of research questions that are relevant and important to communities, foster trusting relationships and secure buy-in that supports research execution, and builds the foundation for effective dissemination and implementation through stakeholder involvement (Concannon et al., 2012; Esmail, Moore, & Rein, 2015; Franck et al., 2018; Higgins, Mullinax, Trussell, Davidson, & Nelwyn, 2018; Mullins, Abdulhalim, & Lavallee, 2012).

The Aim 2 findings suggest the need to improve contraceptive service delivery to women with diabetes. The Aim 3 findings suggested that the 40% of women not using prescription contraception had a lower perception of the benefits of contraception and preconception care. However, only a small fraction of postpartum women with diabetes prepared for their pregnancy by optimizing glycemic control even when they had a highly planned pregnancy. I began the study with the premise that contraceptive use supports the establishment of preconception glycemic control. However, many women with diabetes may not be conceptualizing these linkages and my research needs to be better grounded in their conceptualizations, experiences, and priorities if I am to develop relevant interventions in the future. As I build on my dissertation findings, I want to assure there is alignment with priority concerns of the women most affected.

I plan to deepen my understanding of their perspectives by eliciting their unanswered questions about how diabetes affects pregnancy, how to reduce the risk of pregnancy complications, and how diabetes-specific preconception and prenatal care are delivered. My next major research endeavor will be based on findings I will obtain from implementing the Research Prioritization by Affected Communities (RPAC) protocol (Franck et al., 2018). In partnership with members of the planning group and CBOs, I will identify a list of high-priority, answerable research questions concerning sexual and reproductive health for women with diabetes that are particularly relevant to women who are non-Hispanic black, Hispanic, and/or with obesity. In the RPAC method, participants may identify questions for which research is needed, as well as questions for which there is robust scientific literature. The former can direct future research and the latter can highlight women's unmet information needs. Together, these findings will guide the development of future interventions that are acceptable, accessible, and effective for the women at greatest risk of experiencing pregnancy complications secondary to elevated blood glucose.

Implications for Policy

The findings from this study have implications for the policy responsible for uninsured and underinsured Americans. Among the women who lacked health insurance, 7.7% had diabetes, 47.7% were undiagnosed, 63.8% had an A1C $\geq$ 6.5%, and 22.6% used no contraception (Britton, Hussey, Crandell, et al., 2018). In Aim 3, insurance status did not have a significant association with contraceptive use in our small sample. Nonetheless, it was notable that 20% of participants reported having no insurance, which was somewhat surprising since pregnancy Medicaid is available at the minimum through 60 days postpartum (North Carolina Department of Health and Human Services, 2018).

When young adults lack access to care, they can accrue years of undiagnosed or unmanaged chronic illness that cannot be quickly changed with prenatal care. The accessibility of presumptive Medicaid for pregnancy is critical, but perhaps, too little and too late. Consistent access to primary care is needed to achieve and sustain glycemic control before conception. A paradigm shift is needed in programming to support maternal and child health that begins long before pregnancy and extends beyond the "women's health" domain.

Addressing the racial and ethnic disparities in maternal mortality and improving women's pregnancy experiences is a prominent topic in national conversation (Haskell, 2018; N. Martin, Cillekens, & Freitas, 2018) and advocacy (Yale Global Health Justice Partnership & Black Mamas Matter Alliance, 2018). It is a pivotal time to identify strategies for improving maternal and child health that are salient to women who are managing chronic health conditions.

The U.S. lacks a publicly-funded universal healthcare system, and attempts to expand coverage by expanding eligibility for Medicaid were stymied by 18 states after the Supreme Court ruled in National Federation of Independent Businesses vs. Sebelius against a mandatory expansion of eligibility criteria to 138% of the federal poverty level (Antonisse, Garfield, Rudowitz, & Artiga, 2018). In North Carolina, Medicaid eligibility for parents in a family of three ends at 43% of the federal poverty level and for an individual, at 0% (Kaiser Family Foundation, 2018). Alabama, Florida, Georgia, Idaho, Kansas, Mississippi, Missouri, Nebraska, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, Wisconsin, and Wyoming also rejected Medicaid expansion (Kaiser Family Foundation, 2018). Those states constitute the majority of the "diabetes belt" where at least 11% of residents have a diagnosis (Barker et al., 2011). It is not insignificant that the eligibility criteria for Medicaid during pregnancy are more expansive, and most women can obtain Medicaid coverage for prenatal care, delivery, and 60 days postpartum, at minimum (North Carolina Department of Health and Human Services, 2018). However, our findings demonstrate worrisome trends in women's health before pregnancy, which cannot be corrected with prenatal care after the pregnancy has commenced.

Implications for Practice

Our findings of the high rates of undiagnosed diabetes are troubling, but modifiable, and highlight the importance of routine guideline-concordant screening for diabetes. Dall et al. estimated that 58% of adults with undiagnosed diabetes had a healthcare visit in the previous year, and had ADA screening criteria been applied, two-thirds of undiagnosed adults would have been diagnosed (ADA, 2018; Dall et al., 2014). Universal screening is recommended at age 45, but before then, criteria are based on risk factors (ADA, 2018). Vigilance among women under 45 years old should be encouraged based on our findings that most women with diabetes aged 24-32 have an A1C $\geq$ 6.5% (74.7%). Future research should investigate the reasons that providers are not screening adults in healthcare encounters and develop interventions to progress towards guideline-concordant care. Attention should be paid to system-level facilitators and barriers.

Why a disproportionately high rate (75.6%) of diabetes among non-Hispanic black women with diabetes were undiagnosed demands further scrutiny. Identifying why these women were undiagnosed is beyond the scope of this study. We noted that 45.1% of non-Hispanic black women were using contraceptive methods that required a prescription, suggesting that family planning visits are a potential opportunity to screen for diabetes. Since unmanaged diabetes has dire consequences for reproduction, this screening can be conceptualized as supporting the goals of a family planning clinic. Promisingly, 79% of federally funded family planning clinics reported conducting diabetes screenings (Zolna & Frost, 2016). However, it is unspecified if those sites offered the diagnostic protocol with repeat testing in accordance with ADA guidelines. If family planning clinics are conducting original screening tests, the breakdown may be occurring if women lack access to a primary care provider from whom to obtain an official diagnosis and ongoing diabetes management.

Women whose diabetes is undiagnosed are not, by definition, visible to healthcare providers as needing preconception care concurrent with ADA guidelines. Their presence suggests the importance of comprehensive reproductive health services being offered to all women because an unknown proportion has unidentified health issues that can complicate an unintended pregnancy.

For women with diagnosed diabetes, the ADA recommends that family planning counseling is delivered beginning in adolescence (ADA, 2018). However, multiple studies have suggested that women with diabetes are not consistently receiving such care in adolescence or adulthood (Kallas-Koeman, Khandwala, & Donovan, 2012; Schwarz et al., 2017), which is also supported by our findings in Aims 2 and 3. The prevalence of A1C $\geq$ 6.5% and non-use of highly effective contraception highlight the importance of adhering to this recommendation throughout the life course. We found that a small fraction of our postpartum sample had attempted to lower their blood glucose before pregnancy, suggesting that this link must be made more salient to women with diabetes. Attenuating the risks associated with poor glycemic control with preconception care should be a practice priority because it has the potential to reduce adverse obstetrical outcomes, which incur tremendous suffering and cost (Peterson et al., 2015; Wahabi et al., 2012).

Limitations specific to each Aim have previously been discussed in their respective chapters. By design, where Aims 1 and 2 have limitations, Aim 3 has strengths. Aims 1 and 2 only included women from a narrow segment of reproductive age (ages 24−32), whereas Aim 3 included any women over age 18 who were able to become pregnant (ranging from

21−44 years old in our final sample). Aim 3 was a convenience sample of women seeking high-risk obstetrical care at three sites in central North Carolina, and the findings should not be overgeneralized to women in other regions of the country, to women who could not access specialty care, or to the women who did not participate, either because they declined, were unable to be contacted (including because they lost the pregnancy or had a serious malformation), or did not respond when contacted. In contrast, the findings from Aims 1 and 2 were based on a nationally representative sample recruited through schools, thereby avoiding selection bias based on health care utilization (though it should be noted that A1C was not determined for participants who were incarcerated by Wave IV or those who refused to provide biospecimens). Inferences from Aim 3 were limited by the low power due to our small sample size (n = 40), while in contrast, the samples were so large for Aims 1 (n = 6,774) and 2 (n = 5,548) that we may have been prone to finding statistical significance for small effects. Although all aims sought to increase knowledge about women with diabetes, the samples had little overlap. In Aim 1, we included non-pregnant women; in Aim 2, we included non-pregnant women who were sexually active with male partners; and in Aim 3, we included recently pregnant women, regardless of sexual activity. Although the results are not directly comparable, together they provide a more comprehensive representation of women with diabetes at different times of life.

Conclusion

Diabetes is a complicated and expensive chronic illness to manage, representing the single greatest source of annual personal healthcare expenditures in the U.S., currently in excess of $101 billion (Dieleman et al., 2016). As an increasing number of women develop diabetes during their reproductive years, we will likely see more women experiencing diabetes-related complications during pregnancy, which are annually responsible for an estimated $900 million in direct costs and $4.5 billion in lost productivity (Peterson et al., 2015). It is remarkable that women with diabetes can reduce many of those risks to the same levels as women without diabetes simply through improving glycemic control (ADA, 2018). Despite the strong evidence base about how to prevent many diabetes-related pregnancy complications, many women never receive this care because their diabetes is undiagnosed or they experience unintended pregnancies. Since non-Hispanic black women and Hispanic women of reproductive age were disproportionately burdened by undiagnosed diabetes and elevated blood glucose, effectively improving coordination of diabetes management and family planning also has potential to contribute to achieving equity in health through the life course for both adult women and their children. This dissertation highlights areas for improvement in family planning service delivery to women with diabetes and suggests nurturing women's perception of the benefits of timing pregnancies around glycemic control is a promising theory-based strategy for improving contraceptive uptake, particularly in the postpartum period. If the devastating pregnancy complications due to diabetes are to be averted, it is paramount that these findings are the foundation for future intervention development to improve the provision of care to the growing population of women with diabetes during their reproductive years.

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